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JANUARY, 1840.

Practical and Theoretical Mechanics and Chemistry.

Reply to the Remarks of Dr. Hare, on the Essay of Wm. Gries, M. D., relating to the supply of rooms with heated air.

TO THE EDITOR OF THE JOURNAL OF THE FRANKLIN INSTITUTE.

Sir,—I owe it to myself, and to the cause of science, that I should reply to Professor Hare's remarks, published in the October number of your Journal, on my essay, published in the August No. of the same Journal. The reason that I have not attended to this sooner is, that I was absent from my home for two months, and did not see his paper till the last week in December.

When I prepared my essay I wished to occupy as little space in your valuable Journal as possible. The principle appeared to my mind so very plain and simple, that I expected the merely indicating it, to men of science, would be sufficient: but I must have been exceedingly obscure in my language, when such a scientific mind, as the learned professor's, has entirely mistaken my views.

When I first saw his communication, my idea was to leave it, without further comment, to the scientific public, to compare our papers, and to decide upon them; but the public is so much governed by the authority of great names (not having sufficient leisure to examine for themselves)—and the professor's being so deservedly established, by his many claims to priority of discovery, that I fear my humble essay would be entirely overlooked; for I have no other ground than the soundness of my position, and the strength of my arguments to sustain it.

The opinion generally entertained, with regard to introducing heated air into apartments, was that it is immaterial in what direction we bring it in, so that it is near the floor—that it would then diffuse itself as well with one mode of introduction as another, and this opinion I attempted to combat in

my essay. Dr. Hare, no doubt unintentionally, entirely misstates my views, when he says that I "think it expedient to have it enter near or through the floor." This represents me as writing nonsense—for do I not speak distinctly against letting it pass through a hole or grate in the floor? and surely this would be "near or through the floor." The principle that I want to establish is, that the flues or pipes by which the heated air passes off from the heat-chamber, into the apartment to be warmed, in whatever direction they be carried under and through the floor, should not terminate there, but pass above the floor, and there have a horizontal direction, (or parallel with the floor) to some extent, before they terminate. What specific length this horizontal branch should have, it would require many experiments to establish. My horizontal branches were six inches long, as stated in my essay. When I spoke of giving this horizontal direction to the hot air, whilst it was yet in a constrained passage, I thought that if my language was not sufficiently explicit, that the apparatus which I applied and described, would make it plain enough—at any rate, it was intended to convey what I have now in other words described above. The momentum or force which I contend the heated air has, when it issues from the heat-chamber—and which I say so powerfully contributes to carry it to the ceiling, when it passes through a mere opening or openings in the floor, I see Dr. Hare destroys by his arrangement of many small perforations; for, if I understand his language, all his openings, distributed over a surface of thirty feet, are mere openings in the floor, covered with perforated plates, and do not change the vertical current of heated air. Now, for this arrangement of Dr. Hare's I cheerfully concede to him all the credit it deserves, and grant too that he adopted it *not by accident, but upon reflection, and upon principles that he perfectly understands.* But I beg leave to assure him, that if he thinks that these views are parallel with mine, *that he has neither by accident nor reflection fallen on my views.* The momentum or force I speak of is a very desirable agent with me—I do not wish to destroy it,—but to apply it to a very useful purpose, and on this I build my claims of discovery. By bringing the heated air into the horizontal branch or branches of flues, this force is expended in carrying the heated air over the apartment, and into every part of it; that it does this, I have sufficiently established. The column of hot air, as it passes from the flue, meeting with the resistance of the atmosphere, produces a spray, analogous to the spray of water from the branch pipe of a fire engine, and is in this way divided into many parts, and commingles thus with the cold air—every small division passing in the desired direction, until the momentum is expended. And as a part of the spray from a fire engine, when the column of water first divides (the branch pipe being held horizontally) passes upwards contrary to its own gravity, so a part of the spray of heated air passes downwards; as may be readily seen in my arrangement. The horizontal pipes are six inches from the floor, and yet small light articles are blown along the floor to its very extremity. Although my horizontal pipes are six inches above the floor, I feel convinced that it is best to have them much nearer, as I stated in my former essay. To cover my horizontal branches or flues with plates, replete with many perforations, would be as unwise as to cover with a similar plate the branch pipe of a fire-engine.

Respectfully,

Wm. Gries, M. D.

Womelsdorf, Pa., Dec. 30th, 1839.

*History of the Steam Engine, with a reply to the Criticisms to which the first publication of the article gave rise.**

By M. Arago.

[From the Annual of the Board of Longitude, for 1836.]

Translated by Lieut. A. A. Harwood, U. S. N.

The steam engine has already rendered such important services to navigation and the arts, that we cannot be surprised at the eagerness with which researches have been made to ascertain the share which different nations may claim in this admirable invention.

The fact will nevertheless excite some surprise, that in England alone, the booksellers have sold, in a very few years, more than an hundred thousand copies of numerous works, in which this historical question is argued. This brilliant success is, I doubt not, principally due to the lively interest which the steam engine must naturally excite in a country in which it is every where in use; but perhaps, we shall not be far wrong in attributing some portion of it to national pride. Ask, in fact, the members of the House of Lords, and the simple artisan, the city merchant whose brilliant speculations have conducted him to every region of the globe, and the farmer who has never been beyond the limits of his native country; visit the immense manufactories of Birmingham, Manchester, and Glasgow, and the humblest workshop;—everywhere you will be told that the Marquis of Worcester was the first inventor of the steam engine; and after his name, you will find in every body's mouth the names, *all English ones*, of Savery, Newcomen, Beighton, Watt, Hornblower, Woolf, &c. In general, literary persons, and those especially devoted to the cultivation of science, are not more liberal in their opinions upon this subject. In Dr. Rees' Cyclopedia, we find these remarks: 'The Steam Engine follows next to the Ship in the scale of inventions; but in an English Cyclopedia it will take the lead, from the circumstance of its being wholly invented and brought into general use by our countrymen, (article Steam Engine, 2d col.) and eleven lines lower down, as if the first passage was not sufficiently explicit,—'The Steam Engine is the invention of a few individuals, all of them Englishmen.' The celebrated professor John Robison, of Edinburgh, is equally positive. 'The Steam Engine,'says he,' was beyond all doubt first invented by the Marquis of Worcester, in the reign of Charles the Second.' (See a *System of Mechanical Philosophy*, vol. II, p. 46.) After having afterwards refuted, by arguments which I shall examine, the pretensions of French authors, who *affect* to blend the name of Papin with the history of the Steam engine. Robison declares, that he does not hesitate at all to give the honour of the first and complete invention to the Marquis of Worcester. (See *a System, &c.*, page 50.) A *Savant* not less illustrious for depth of knowledge than for vast erudition, Dr. Thomas Young, has added his imposing testimony to those already cited. According to him, the Marquis of Worcester is the first inventor of the Steam Engine, and the first who made use of the pressure of steam as a moving power. In the rapid sketch which he gives of the

*No apology is necessary for presenting to our readers an article of permanent interest, like this, which has been twice published in the Annuaire of the Board of Longitude. We hope that some of our Correspondents may be induced, by seeing the article in English, to set the claims of our countrymen, Rumsey, Fitch, Evans, Stevens, and Fulton, in a more just light than is here done. Com. Pub.

improvements which this machine has successively received, English machinists alone are made to figure, (*Lectures on Natural Philosophy*, vol. 1st, p. 346 a 356,) I might also cite Mr. Millington, the able professor of Mechanics at the Royal Institution, Mr. Lardner, a distinguished member of the New University of London, and Mr. Nicholson, the author of a valuable treatise on practical Mechanics.

Decisions so numerous, so positive, and derived from works of such high reputation did not seem to me, at first, to admit of the shadow of a doubt. When, therefore, at the request of the pupils of the Polytechnic School, I attempted, some years ago, to trace the chronological series of improvements which the steam engine has undergone, from its origin up to the present day, I frankly acknowledge I expected to have none but English mechanicians to quote. This however was an error : our neighbours of the other side of the channel are neither the only nor even the first inventors of the Steam Engine. This at least appears to me to be proved by the passages which I now submit to the readers of the Annuaire. I feel sure, at all events, of having examined this curious point in the history of the sciences without prejudice, and that my citations and analyses may be depended upon as exact. If the deductions from them are not so, the reader will be able to rectify them himself, since he will be furnished with all the elements of the question.

I ought, before concluding this preamble, to observe further that there has recently appeared in England a remarkable work, entitled *a descriptive History of the Steam Engine*, by Mr. Robert Stuart, in which all the attempts which have been made to use steam as a mechanical agent are estimated with a great deal of discernment; and, which is still rarer, with an entire disregard to national prejudice. With few exceptions, the opinions of Mr. Stuart upon the relative merits of the engineers who have contributed to the creation of this wonderful machine, agree perfectly with those which I had formed from the study of the original records. I naturally take advantage of this flattering coincidence with eagerness; I may even add that if my memoir had not been nearly drawn up when Mr. Stuart's history came into my hands, I should probably have been satisfied with the insertion of a simple analysis of his book, by doing which, the end that I proposed to myself would have been equally attained.

I hope the reader will appreciate the motives which have determined me not to follow strictly a chronological order in every part of this article. I have concluded that there would be greater clearness in collecting together the paragraphs relating to the various and more or less advantageous modes which have been successively conceived for the employment of steam.

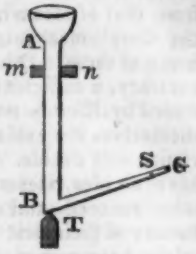
The details of mechanism, though very important, seem to me to be of secondary consideration.

120 *years B. C. Hiero of Alexandria.**

When liquids, gases, or vapours, flow from vessels which contain them un-

*Hiero of Alexandria, lived nearly 120 years before our era. The greater part of the numerous works which he composed are lost; there are only three of them remaining. The reacting machine here in question, is found described, and represented in the treatise, entitled, *Spiritalia seu pneumatica*. The invention of cog-wheels is claimed for Hiero; but this honor belongs, I believe, to his master Ctesibius. His water clocks, and above all, his automata, excited the admiration of antiquity. The fountain which bears the name of Hiero has been applied to various important purposes, even in our days; it serves for instance, in the mines of Schemnitz, in Hungary, as a draining machine.

der certain conditions which I shall describe, they become a cause of motion which it is necessary to estimate properly in order to understand the operation of a little apparatus contrived by Hiero of Alexandria, which offers, I think, the first example of the employment of steam as a motive force.

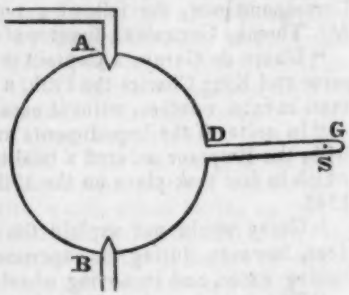


Imagine a bent tube A, B, G, the two branches of which A, B, and B, G, meet each other rectangularly. Let us suppose that the branch B, A, is vertical, that it passes freely through a fixed ring *m*, *n*, and that it rests beneath upon a sharp point T, so as to turn upon itself without interruption. If in this situation water is poured in by the upper funnel, we shall have two distinct cases to consider. When the liquid flows through the extremity G, *in the direction* B, G, the whole apparatus will remain motionless. When, on the contrary, the tube B, G, is stopped at its extremity G, and the liquid escapes only by the *lateral* opening S, in a horizontal direction, the machine will be put in motion. It will turn round A, B, as long as the flow continues, but in a contrary direction to that in which the jet is formed. If, for instance, the water is forced forward, the horizontal tube B, G, will revolve in a contrary direction by a species of recoil.

All the machines in which water has been thus employed, are called *reacting machines.*

A gas passing rapidly through the bent tube A, B, G, would produce the same effects as the water: the tube would be at rest while the gas escaped in the direction B, G; on the contrary, it would turn if the escape took place laterally.

These preliminary considerations will suffice to explain the mode of action of steam in the machine of Hiero.



Let us imagine that a hollow metallic sphere, contrived so as to turn between two pivots A, and B, is filled with a very elastic vapour; that this vapour may escape from the sphere by a projecting tube D, G, perpendicular to A, B, and placed upon the prolongation of one of the radii. We have already seen that if the tube D, G, is open at its extremity, it will not incline to revolve, and that the sphere will remain at rest; and on the contrary, that if the escape takes place by the lateral opening S, in front for instance, the tube will recoil, and will tend to make the sphere to which it is attached revolve with a backward motion. To ensure the continuance of this rotary motion it will suffice to add to the preceding suppositions, that one of the two pivots, (A for instance) is hollow, that it communicates at one end with the inside of the sphere, and at the other with the boiler: the steam expended at S, will in this way be constantly replaced as fast as it escapes.

In the figure which Hiero has given of his little apparatus, two tubes are seen like that which I have just described. They form the opposite prolongations of the same diameter, and their lateral openings are so disposed as to make the sphere turn in the same direction.

There is also in the *Spiritalia* the description of a machine differing from the preceding in this particular only, that a current of heated air takes the place of a current of vapour.

To sum up, we find a certain employment of aqueous vapour in one of the contrivances described by Hiero; but the action of this vapour differs from that of steam in modern machines. Watt, to whom the experiments of the Greek mechanician were not unknown, thought that no use could be made of them. Others, if I am correctly informed, have entertained, on the contrary, a sufficiently favorable opinion of the effects which might be produced by Hiero's mechanism, when perfected, to have sought to secure to themselves the exclusive enjoyment of them by a patent. Time and experience will decide. We see only, that if by modifications of which we now have no idea, steam machines upon a reacting principle shall one day or other succeed, and it is thought necessary to write a history of them, the honour of their first invention must be awarded to Hiero. For my part I might have passed them over altogether in silence, since I have only to do with known machines, such as are in common use, and which have no affinity with the revolving sphere of the Alexandrian philosopher. Perhaps, indeed, it had been proper to cite here in preference, authors, who, like Aristotle, and Seneca, attribute earthquakes to the sudden transformation of water into steam. This change, according to them, takes place in the womb of the earth by subterranean heat, and the prodigious effects which they endeavor to account for, shew clearly the enormous mechanical power they imputed to steam. I hope, at all events, that this article may find excuse when it is seen that it gives a natural solution of the important question to which the paper which I am now going to take up has given rise.

1543. *Blasco de Garay.*

M. de Navarrete, published in 1826, in the Baron de Zach's Astronomical Correspondence, the following note, which was communicated to him by Mr. Thomas Gonzalez, director of the royal archives of Simuncas.

"Blasco de Garay, a Captain in the Navy, proposed in 1543, to the Emperor and King Charles the Fifth, a machine to propel large boats and ships even in calm weather, without oars or sails.

"In spite of the impediments and the opposition which this project met with, the Emperor ordered a trial to be made of it in the port of Barcelona, which in fact took place on the 17th of the month of June, of the said year, 1543.

"Garay would not explain the particulars of his discovery; it was evident, however, during the experiment, that it consisted in a large copper of boiling water, and in moving wheels attached to either side of the ship.

"The experiment was tried on a ship of 200 tons, called the Trinity, which came from Colibre, to discharge a cargo of corn at Barcelona, of which Peter de Scarza was Captain.

"By order of Charles V, Don Henry de Toledo, the Governor, Don Pedro de Cordova, the Treasurer, Ravago, and the Vice Chancellor, and Intendant of Catalonia, witnessed the experiment.

"In the reports made to the Emperor, and to the Prince, this ingenious invention was generally approved, particularly on account of the promptness and facility with which the ship was made to go about.

"The Treasurer, Ravago, an enemy to the project, said that the vessel could be propelled two leagues in three hours; that the machine was too complicated and expensive, and that there would be an exposure to danger

in case the boiler should burst. The other Commissioners affirmed, that the vessel tacked with the same rapidity as a galley manœuvred in the ordinary way, and went at least a league an hour.

"As soon as the experiment was made, Garay took the whole machine with which he had furnished the vessel, leaving only the wooden part in the arsenal at Barcelona, and keeping all the rest for himself.

"In spite of Ravago's opposition and contradiction, Garay's invention was approved, and if the expedition in which Charles V, was then engaged had not prevented, he would no doubt have encouraged it.

"Nevertheless, the Emperor promoted the inventor one grade, made him a present of 200,000 maravedis, ordered the expense to be paid out of the Treasury, and granted him besides many other favours.

"This is derived from the documents and original registers kept in the Royal Archives of Simuncas, among the commercial papers of Catalonia, and from those of the military and naval departments for the said year, 1543.

"THOMAS GONZALEZ.

"*Simuncas, August* 27, 1825."

According to M. Navarrete, it follows from the note which we have just read that, *the invention of steam vessels is Spanish, and has only been revived in our days.* From this, also, is deduced another consequence, viz: that Blasco de Garay ought to be regarded as the real inventor of the steam engine.

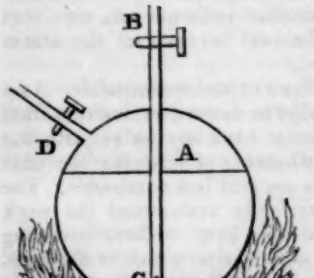
These pretensions seem to me to be from their nature inadmissible. As a general position the history of the sciences should be derived exclusively from printed papers. Manuscript documents cannot have any value with the public, because, generally, it has no means whatever of verifying the date assigned to them. Extracts from manuscripts are still less admissible. The author of a review does not, sometimes, perfectly understand the work which he attempts to analyse, and he substitutes, even without intending it, popular opinion, or his own, for the ideas of the writer which he abridges. I will concede, however, that neither of these difficulties is applicable to the present case; that the document quoted by M. de Navarrete is actually one of 1543, and that the extract of M. Gonzalez is authentic: but what then?—Why in 1543 an attempt was made to propel vessels by a certain mechanical means, nothing more. The machine, it is said, contained a boiler, and therefore it was a steam machine. This reasoning is not at all conclusive. There exists, in fact, in various works, plans of machines, in which fire is seen under a boiler filled with water, steam having no part in the matter; such, for instance, is the machine of Amontons. After all, even if we were to admit that the machine of Garay was set in motion by steam, it would not necessarily follow that the invention was new and that it bore any resemblance to those of our day, because Hiero, as we have already seen, described 1600 years before, the means of producing a rotary motion by the action of steam. I will even add that supposing the experiment of Garay to have taken place, and that his was really a steam machine, every thing would lead us to believe that he employed the eolipile of Hiero. This apparatus, in fact, could not be of very difficult construction, since we may boldly affirm, that the simplest of our modern steam machines would require a nicety of workmanship vastly beyond any thing which could have been obtained in the sixteenth century. Besides, Garay having refused to explain his machine to any one, even to the commissioners nominated by the Emperor, every attempt which may be made after the lapse of three

centuries to establish in what it consisted, will evidently lead to no certain result.

To recapitulate: the new document brought to light by M. de Navarrete ought to be set aside, in the first place, because it was not printed in 1543 nor since; secondly, because it does not prove that the impellant of the Barcelona ship was a real steam machine; thirdly, because if a steam machine by Garay ever did exist, it was, according to all appearance, the reacting eolipile already described in the works of Hiero, of Alexandria.

1615, *Solomon de Caus.**

Solomon de Caus is the author of a work entitled, *The reasons of moving powers, with diverse machines both useful and entertaining.—(Les Raisons des forces mouvantes, avec diverses machines tant utiles que plaisantes, etc.* This work appeared at Frankfort in 1615. We there find, among other ingenious things, that many mechanicians have presented in our day as new, a theorem thus conceived, under No. 5. *Water by the aid of fire will ascend above its level.* Here are the terms in which de Caus justifies this assertion.



"The third means of making water rise is by the aid of fire, by which means various machines may be made. I will give here the demonstration of one of them.

"Let there be a copper ball marked A, well soldered all around, to which there shall be a vent, marked D, by which water may be introduced, and also a tube marked B, C, which shall be soldered at the top of the ball, and the end of which C, shall nearly reach the bottom without touching it; then the said ball must be filled with water through the vent and then be well closed and placed upon the fire; then the heat acting upon the said ball, will cause all the water to rise through the tube B, C."

The apparatus, a description of which I have just transcribed, is a true

* By a caprice, well worthy of remark, a man whom posterity will regard, perhaps as the first inventor of the steam engine, is only cited in Montucela's history of the mathematics on account of his treatise upon perspective, and then the citation consists of only five words. He has also barely obtained the honour of an article of a few lines in the voluminous biographical dictionaries of our own day. The universal biography gives him birth and a grave in Normandy. It says that he lived in England for some time, where he was attached to the household of the Prince of Wales. In *The reasons of moving forces*, Solomon de Caus takes himself the title of "*Engineer and Architect of his Highness the Elector Palatine.*" This work was composed, I believe, at Heidelberg; it was printed at Frankfort; these three circumstances have given rise to the idea that de Caus was a German. But let us remark, in the first place, how improbable it is that a German would have written in French in his own country. Add to this, that in his dedication to his most Christian Majesty (Louis XIII) the following formula precedes the signature: de votre Majesté, le tres obéissant SUBJECT; that finally, we read in the license, and this cuts short all doubt: "Our well beloved Solomon de Caus, master engineer, *being at present* in the service of our dear and well beloved cousin, the Prince Elector Palatine, has caused us to be informed, etc. * * Wishing to gratify the said de Caus he being *our subject*, etc." Thus we find that Solomon de Caus was a Frenchman.

steam draining machine. But perhaps it might be supposed, if I were to limit myself to the preceding passage, that Solomon de Caus was ignorant of the cause of the ascension of the fluid through the tube B,C. It was, however perfectly known to him, a proof of which may be found in his first theorem, p. 2 and 3, where, in a similar experiment, he says that "the violence of steam (produced by the action of fire) which causes the water to rise, proceeds from the said water, which steam will escape, after the water shall have gone out through the cock, with great violence."

1629. *Branca.*

Branca is the author of a compilation entitled: *Machines of Sig. G. Branca; Rome*, 1629. This work contains the description of all the machines with which the author had become acquainted. Among these we remark an eolipile placed on a brazer, and arranged in such a way that the current of steam rushing through a tube should strike the wings or the buckets of a small horizontal wheel and cause it to turn. The wind from the nozzle of an ordinary bellows would evidently have produced the same effect. I have not been able to comprehend the analogy by which persons have perceived in this eolipile the first germ of the steam engines of the present day. At all events, and I shall limit myself to the remark, that the compilation of Branca bears a much later date than the first two editions of the work of Solomon de Caus.

1663. *The Marquis of Worcester.**

The Scantling of one hundred inventions, by the Marquis of Worcester, appeared in 1663, in the reign of Charles II. This book is more generally known by the title of the *Century of Inventions*. The apparatus which English authors regard as the *first steam engine (la première machine à feu)* is described in these terms, under the head of the 68th invention:—

"An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be, as the philosopher calleth it, *intrà sphæram activitatis*, which is but at such a distance. But this way hath no bounder, if the vessel be strong enough; for I have taken a piece of a whole cannon, whereof the end was burst, and filled it three-quarters full of water, stopping and screwing up the broken end as also the touchhole; and making a constant fire under it, within twenty-four hours it burst, and made a great crack: so that having a way to make my vessels so that they are strengthened by the force within them†, and the one to fill after

* Edward Somerset, Marquis of Worcester, whom the English regard as the true inventor of the steam engine, lived in the reign of the last of the Stuarts. Involved in all the intrigue of this epoch, he suffered many vicissitudes. Worcester lost, at first his immense fortune; went into Ireland; was there imprisoned; made his escape and reached France; returned to London by the orders of Charles II, was discovered and imprisoned in the Tower from which he was not released until the restoration. Tradition relates that the ideas concerning the uses in which it would be possible to employ the power of steam, were awakened during his last imprisonment by the sudden raising of the lid of the pot in which his food was cooked. The anecdote, if true, does honour to the inventive genius of the prisoner; but shews, at the same time, his want of erudition; because it must be admitted that he was not acquainted with the work of Solomon de Caus, a second edition of which had appeared in France while Worcester resided there.

† It has appeared to me that *force within them* cannot mean the means of interior consolidation. If I understand the expression, Worcester, in order to answer an ob-

the other. I have seen the water run like a constant fountain stream forty foot high; one vessel of water rarefied by fire driven up forty of cold water. And a man that tends the work is but to turn two cocks, that, one vessel of water being consumed, another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the self-same person may likewise abundantly perform in the interim, between the necessity of turning the said cocks."

The reader knows now all that the Marquis of Worcester has ever written upon the steam engine. It is the sole title upon which Mr. Partington, of the London Institution, in his new edition (1825) of the *Century of Inventions*, founds his decision and that of his countrymen, that "Worcester is the first discoverer of a means of applying steam as a mechanical agent; an invention which is alone, he adds, sufficient to immortalize the age in which this man lived." Let us, in our turn, examine this paragraph, so often cited, and see impartially what is to be found there.

I perceive in it, at first, an experiment which shows that water reduced to steam, can, in time, burst the sides of the vessel in which it is confined. This experiment was known in 1605, for Flurence Rivault says expressly that the eolipile bursts with a loud report when the steam is hindered from escaping. He adds even: *the effect of the rarefaction of water is enough to dismay the boldest men.—(Elémens d'artillerie, p.* 128, *Paris*, 1605.*)

I perceive, secondly, the idea of raising water by the aid of the elastic force of steam. This idea belongs to Solomon de Caus, who had published it forty eight years before the English author.

Finally, I find in it the description of an apparatus proper for producing this effect; but which does not recognize that the metallic ball of Solomon de Caus would raise water also to any height, supposing its sides to be strong enough and the heat to be sufficiently intense. Perhaps it will be said that the machine of the Marquis of Worcester is the better of the two. I may grant all this without its being of any consequence since it is not now a question to discover who was the most ingenious in contriving steam en-

jection which he foresaw, found it convenient to assure us that his new boilers would never burst, and in fact he would have attained that object, if, as he said, they would become stronger in proportion to the intensity of pressure of the steam outward. This circumstance will give new weight to the opinion of those who think that Worcester never made trial of his machine; but I hasten to remark that all this is unimportant as far as the question of priority under discussion is concerned. AUTHOR.

This hypercriticism loses its force entirely when the true meaning of Worcester's assertion is considered. He does not say that the vessels are strengthened by the force of the steam within them but by "the force," alluding, obviously, to the means employed for strengthening. TRANS.

* I borrow this quotation from one of the curious historical articles so rich in erudition, which M. Montgéry has published upon machines, in which fire is in any manner employed, and I have substituted it for the following passage of Solomon de Caus which I had at first inserted in the text. This passage appeared but ten years later; that is to say in 1615; nearly fifty years, however, before the *Century of Inventions*: "The violence will be great when the water evaporates in air by means of fire, and when the said air is enclosed; as, for instance, let there be a ball of copper of one or two feet in diameter, and an inch thick, which shall be filled with water through a little hole, which shall be well stopped by a nail, so that the water cannot escape from it; it is certain that if the said ball be placed on a large fire so that it becomes very hot, that it will cause a compression so violent that the ball will burst in pieces with a noise like that of a petard." (Les Raisons des Forces mouvantes, livre première, feuille première.)

gines, but simply who it was that first thought of making use of the elastic force of steam to raise a weight or to produce motion. Moreover, before comparing the plan of the Marquis of Worcester with others, it is necessary to know exactly in what the first consisted. This problem has not yet been solved, for the simple reason that the description of the sixty-eighth invention of the English peer is entirely deficient in perspicuity. Nobody in the present day, would find any difficulty in constructing a draining machine in which water would be raised by the action of steam; but when the question arises, to reproduce that of the Marquis of Worcester, we must limit ourselves to do what the author says, and no more.

In imposing upon himself these two conditions, Mr. Stuart decides that we shall approach, as near as possible, to the description of his countryman, by combining two of Solomon de Caus' machines in such a way as to produce, by their alternate action, a continual efflux. The other solutions which have been given, so far, of the same question, that of Millington, for instance, are evidently inadmissible.

When Messrs Thomas Young, Robison, Partington, Tredgold, Millington, Nicholson, Lardner, etc., brought forward the Marquis of Worcester as the inventor of the steam engine, the work of Solomon de Caus was, no doubt, unknown to them.

Since it is now established, beyond dispute, that the first idea of raising a weight by means of the elastic power of steam belongs to the French author; that if even the machine of his competitor ever existed, it was, according to all appearances, the apparatus described nearly half a century before in the work entitled *Raisons des forces mouvantes;* it is to be supposed that future historians will not fail to inscribe the modest name of Solomon de Caus, wherever, up to this time, that of the Marquis of Worcester has taken precedence.

1683. *Sir Samuel Morland.**

If I were only to speak in this memoir of those persons whose works have contributed either to create or to improve steam machines, the name of Sir Samuel Morland would be omitted altogether; but this name being on the lips of almost every author in England who has treated of the steam engine, I cannot well omit mentioning it myself, if it were only for the purpose of justifying the opinion which I am about to advance. There is in the British Museum a very beautiful manuscript of Sir Samuel's, entitled, The elevation of water by all kinds of machines, reduced to measure, weight, and level; presented to his most Christian Majesty by the Chevalier Morland, gentleman in ordinary of the privy chamber, chief machinist, and master of mechanics of the king of Great Britain.† In this manuscript of thirty-eight pages, the article relating to the steam machine only occupies four pages, and is distinguished from the rest by a particular title. Here is the para-

* Sir Samuel Morland, as well as Worcester, took an active part in the events of the civil war. Cromwell employed him in many diplomatic missions. His countrymen assure us, that he was, at the same time, secretary to Thurlow and notoriously a spy of the king. At the restoration, Charles II made him a baronet. Morland employed himself in various questions of acoustics, among others, of the best shape to give the speaking trumpet. He died at Hammersmith in the month of January, 1696, after having conceived the odd idea of causing a large collection of works on music which he possessed to be buried six feet deep, in token of repentance for his past life.

† There exists one of Morland's works, *printed* in Paris in 1685, which has nearly the same title as the manuscript of the British Museum. The chapter relating to the steam engine is wanting. The author only, in enumerating, in his preface, all the

graph upon which the pretensions of Morland as a contributor to the creation of the steam engine are founded in England:—

"Water being evaporated by the action of fire the steam thus produced requires immediately nearly 2000 times greater space than the water occupied before, and sooner than remain confined would burst a piece of ordnance. When subjected, however, to the laws of statics and reduced by science to measure, weight and equipoise, then it will bear its burden like a good horse, and will thus become of great use to the human race, particularly in the raising of water, according to the following table which marks the number of pounds which may be lifted 1800 times an hour at six inches of lift, by cylinders half filled with water, as well as the diameters and depths of the said cylinder."

If Morland's work had preceded those of Solomon de Caus or of Worcester, the passage which I have just read would constitute a true claim. In 1683, that is to say, sixty-eight years after the publication of *Raisons des Forces mouvantes*, and twenty years after the date of Worcester's patent, Morland's plan could be only considered as a plagiarism. Be it said, however, to the honour of this mechanician, that the numbers which he gives to express the relative bulk of water and of an equal weight of steam, come nearer to the truth than might have been expected from experiments made in 1682.

1690 *and* 1695. *Denis Papin.**

Fig. 1.

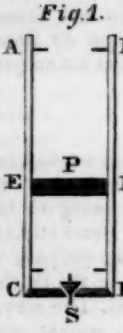
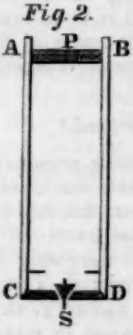


Fig. 2.



Let us imagine a large vertical cylinder A, B, C, D, fig. 1, entirely open on the upper part, and resting upon a metallic base, furnished with a valve capable of opening from below upwards at pleasure. Let us place a movable piston P in the middle of the cylinder closing its opening very exactly. The atmosphere will press with all its weight upon the upper surface of this piston, and will force it from above downwards. If the valve S, is open, that portion of air with which the space D, C, E, F, is filled, will tend, on the contrary, by its reaction to raise the piston again. This second force will be equal to the first, because in a gas, as well as in a fluid, the

various motive powers which the mechanician brings into play, mentions the force of gunpowder and that of steam, without making any remark on this subject, by which we may infer whether he sets himself up as an inventor, or speaks of a thing already proposed by others.

* Denis Papin was born at Blois. In his youth he devoted himself to medicine and took his degrees in Paris; afterwards he crossed over to England where Boyle, who had associated him with some of his experiments, caused him to be nominated a member of the Royal Society in 1681. Being obliged to expatriate himself by the revocation of the edict of Nantes, Papin took refuge in Germany, under the protection of the Landgrave of Hesse, and filled with distinction for many years, the situation of Professor of Mathematics in the university of Marburg; he died in 1710. It must be considered as singular that the academy of sciences at Paris should not have named Papin one of their associates, when we reflect that in 1690 he published a memoir in which is found, as we shall see directly, the most methodical and the clearest description of the steam engine known at present under the name of the *Atmospheric Engine*, and even of that of *steam vessels*. A man of genius, no matter in what line, is always despised when he is in advance of the age in which he lives.

pressure in each point is the same in all directions. The piston thus acted upon by two opposing forces, which balance each other, will, nevertheless, descend, but only by its own weight. Any effort then, however small, if superior to this same weight will be sufficient to raise the piston to the top of the cylinder and keep it there. Let us suppose that in fact the piston is thus brought to the end of its course, as it is represented in fig. 2, and let us try to make it descend. A very efficacious way would consist in shutting the valve S, and afterwards, if it were possible, to annihilate suddenly and entirely in the cylinder that portion of air which occupies the space A, B, C, D. Then the piston would only be subject to the action of the outer air by which it is pressed. This impulse would be exercised on its upper surface, from above, downwards, and would be in measure, equal to a cylinder of water of thirty-three feet in height, the base of which would be equal to that of the piston, or, which amounts to the same thing, to the weight of a cylinder of mercury of a similar base, and thirty inches only in height; for such is the weight of the atmosphere. The piston would then descend necessarily, and could even drag with it a weight equal to that of the cylinder of water or of mercury of which I have just spoken. Following still the same hypothesis, let us admit that at the instant in which the descending movement is completely accomplished, the valve S is opened. The air will operate from below and will counterbalance the action of the air above. A trifling impulse will then suffice to force the piston back to the top of the cylinder and to bring back every part of the apparatus to its first position. A second exhaustion of the inner air would cause the piston to descend again, and so on in succession.

To recapitulate:—in this apparatus, a small expenditure of power is sufficient to raise the piston, whilst its descending motion is capable of producing a considerable effect. If a cord is attached by one end to the centre of the piston, and the other end is passed over a pulley, we may at each descending motion raise a very great weight, equal in amount to the height of the cylinder. With a cylinder one hundred square inches in area the weight raised at each descending stroke of the piston, would be 1500 pounds.

The idea of the machine of which I have just spoken belongs to Papin. It is very clearly explained in the Acts of Leipsic, for the year 1688, p. 644, and subsequently with some new developments in a letter to Count William Maurice. (See the work printed in Cassel, in 1695, and entitled: *Recueil de diverses pièces touchant quelques nouvelles machines, p. 38 et seq.)* It now remains for us to make known the means by which Papin proposed to exhaust, at the proper moment, the atmospheric air which, collected under the piston, would hinder its descending motion, or, what amounts to the same, it remains for us to explain how he made, at pleasure, a vacuum in the lower part of the cylinder.

This philosopher thought for some time of employing for that purpose a hydraulic wheel which would have set the piston of a common suction pump in motion. When the water course employed to set this wheel in motion should be too far from the machine, he proposed to connect it with the pump by the intervention of a continuous tube, like the gas pipes of our days: this was, he said, *a means of transporting water power from a distance.* [*Un moyen de transporter fort loin la force des rivières.*]

In this state, in 1687, the machine was presented to the Royal Society of London, where it gave rise to some difficulties which Papin mentions, without saying, however, in what they consisted. (See Recueil, p. 41.) He

had tried previously to make the *vacuum* under the piston by means of powder; but "notwithstanding all the precautions which have been observed," says he, "there has always remained in the tube about a fifth part of the air which it usually contains, which causes two different inconveniences. One is, that half the power which we ought to obtain is lost, so that we could only raise one hundred and fifty pounds to every foot in height, in place of three hundred pounds which ought to be raised if the tube had been perfectly emptied; the other inconvenience is that in proportion as the piston descends, the power which pushes it down diminishes more and more, etc. (Recueil, etc., p. 52.)

"I tried then, he adds, to succeed in another way; and as water being changed by fire has the property of becoming elastic as air, and afterwards of recondensing itself so completely BY COLD that it retains no appearance of this elastic power, I have thought that it would not be difficult to construct machines in which, by the means of a moderate heat and at little expense, water would create this perfect vacuum which has been fruitlessly attempted by the means of gunpowder."

This important paragraph is found in the 53rd page of the collection, printed at Cassel in 1695, as extracted from the Acts of Leipsic, of the month of August 1690. It is followed by the description of the little apparatus which Papin made use of to try his invention. The body of the cylinder was only two and a half inches in diameter and weighed but five ounces. At every vibration it raised sixty pounds, however, a distance equal to that of the descending stroke of the piston.

When the fire was removed, the steam disappeared so completely that the piston to which it had given the ascending motion "redescended to the very bottom, so that it could not be suspected that any air remained to act on it from below and resist its descent." (Recueil, p. 55.)

The water which furnished the steam in these first experiments, was not contained in a separate boiler, it was contained in the body of the cylinder itself, resting upon the metallic plate which closed it below. Papin heated this plate directly to convert the water into steam; and cooled it by removing it from the fire when he wished the steam to condense. He relates that with a moderate fire, a minute was long enough, in the experiments of 1690, "to drive the piston in this way to the very top of its tube." (Recueil, p. 55.) But in the experiments which he afterwards made he emptied the tube in a quarter of a minute.

Moreover, he himself declares that setting out from the principle of the condensation of steam by cold, the end proposed may be attained "by different constructions easy to imagine." (See the Recueil, p. 53.)

The machine of Solomon de Caus and that of the Marquis of Worcester were intended for draining. Such also was the principal use which Papin expected to derive from his atmospheric pressure engine; but at the same time he saw perfectly that the reciprocating motion of the piston in the cylinder was capable of other applications and might become an universal motor. We find, in fact, in page 58 and 59 of the *Recueil*, and even before it in the Acts of Leipsic of 1690, a plan for converting this alternate movement into one of rotation. I will not dwell longer here upon this subject since we shall have to resume it further on in treating of steam vessels, and I will finish with Papin by presenting to the reader the various consequences which appear to me to flow from the extracts which we have just read.

Papin conceived the first steam engine with a piston.

Papin first observed that aqueous vapour furnished a simple means of rapidly creating a vacuum in the space contained in the cylinder.

Papin is the first person who thought of combining in the same machine operating by fire, the action of the elastic force of steam, with the property which steam possesses, and which he has described, of condensing by cooling.*

1698. *Captain Savery.*

We have no proof that Solomon de Caus ever caused his steam engine

* Messrs. Stuart and Partington have explicitly recognized all these claims of Papin to the gratitude of mechanicians; but, by way of equivalent, those who read Dr. Robison's History of the steam engine (see the last edition with the comments of Watt) will there find, p. 49, that the *first publication* of Papin upon steam machines appeared in 1707; that this machinist did not propose to employ a true piston but a simple float; that he had never dreamed (and here was the important point) of producing the descending motion of the piston by the condensation of steam. These declarations are also made in Dr. Rees' Cyclopedia, article Steam Engine. The author of this article has read in the Acts of Leipsic, a description of the machine in which Papin attempted to produce a vacuum by the aid of gunpowder, for he quotes it; but, by a singular fatality, the mention inserted in the same Acts, of Papin's substituting steam for powder did not attract his attention, since he declares that the apparatus of the French machinist was never *intended to be worked by steam.*

Mr. Millington is hardly more favourable to our countrymen whose ideas, he says, upon the means of producing a motive power by the aid of steam are all posterior to Savery's patent (p. 255); (Savery's patent was issued in 1698.) Mr. Lardner assures us equally in the lectures which he has recently published, that the French ground their pretensions to the invention of the first steam engine, upon a work of Papin's which did not appear until 1707, nine years after the date of Savery's patent. This remark, he adds, settles the question entirely; Papin has no right to any share in the invention of the steam engine. *(Voyez Leçons Sur la machine à vapeur, p.* 96, 97, *et* 101 *de l'édition française.)*

Is it not really singular that the greater part of the English authors persist in this way in citing only one of Papin's works, that of 1707; that they will make no account of the much more voluminous work from which I have borrowed several passages, and of which two editions appeared in the same year, 1695, one at Cassel in French, and the other at Marburg in Latin; that all the records of this author inserted in the Acts of Leipsic appear to them as if they had never existed!

I will grant, if they will, that there was no piston, properly so called, in the *draining* machine of 1707; that the condensation of steam had nothing to do with it; that, at all events, the machine is of posterior date to Captain Savery's patent; but these concessions lead to no conclusion, since we do not cite the work of 1707, but a collection of 1695, and the Acts of Leipsic of 1690. Bossut derives his authority, in his *Hydrodynamique*, for attributing to Papin an important part in the invention of the steam engine, from the work of 1695; Robison answers that this work does not exist! ("*The fact is that Papin's first publication was in* 1707.") I might conceive of a declaration that he had never seen it, but this flat denial, opposed to the positive assertion of Bossut, was the more strange, because Papin's book is not scarce in England, and because, at all events, the Acts of Leipsic which contain the substance of it, are to be found in the principal libraries, and finally because this work, the existence of which is denied by the celebrated Edinburgh professor, was announced and reviewed in March 1697, in the *Philosophical Transactions*, a year before any thing was said about Savery's engine. It should not be forgotten that the review of the Philosophical Transactions gives, in another place, that passage in Papin's work which relates to the employment of steam, in the first place as a means of working the piston, and afterwards as a means of creating a vacuum in cylinders. (See Trans. vol. XIX, p. 483.)

to be constructed. I might say as much of that of the Marquis of Worcester.* Papin's machine, in which the action of steam and its condensation came successively in play, was only executed on a small scale, and only with the view of establishing experimentally the accuracy of the principle upon which it is founded.†

Moreover, although, properly speaking, there may be nothing very new in Savery's steam engines, they could not without great injustice be passed over since they are really the first which were probably in operation. Moreover, I do not think it necessary here to give a drawing of them: the reader can, without this assistance, form an exact idea of them if he will recall to mind that of Solomon de Caus and pay some attention to the following considerations. According to de Caus' plan, the steam which was to give the power would be generated in the vessel which contained the water to be raised, and at the expense of this same water. In Savery's machine, there are two separate vessels; one contains the water, the other, which might be called the *boiler*, contains the steam. This steam, when it is thought to be sufficient in quantity, is admitted into the upper part of the vessel of water through a communicating tube which is opened at pleasure by the aid of a cock. It acts downwards upon the surface of the liquid and drives it into a vertical tube, the lower opening of which ought to be always situated below this surface, otherwise the steam would escape through it. Up to this point the difference between the two machines is insignificant; let us continue the comparison.

In the machine of Solomon de Caus, as soon as the pressure of the steam has produced its effect, a workman replaces the expelled water by means of an orifice situated in the upper part of the metallic sphere, and which can be opened or closed at pleasure. Nothing more remains to be done then but to increase the fire. In Savery's machine, the vessel which is to contain the liquid is not supplied by a workman, but by means of atmospheric pressure. The steam driving before it, during the first period of its action, the water which the vessel contained, takes its place; now, the steam, whatever may be its original elastic power, must be condensed, in a great measure, if its temperature be much lowered. It is sufficient for this purpose, and such in fact is the process adopted by Savery, to throw cold water upon the sides of the vessel, containing it. After this operation, the atmospheric pressure easily surmounts the barely perceptible elasticity which the cooling has not annihilated, and if the vessel communicates by a

* The privilege solicited by the Marquis of Worcester was granted him according to Walpole, *upon the simple assurance* which he gave the commissioners named for this purpose, that he had invented a machine operating by the action of steam. If the machine had been really constructed, the remark relative to the declaration, as Mr. Stuart observes, had not been necessary. I am not ignorant that ultimately, it has been pretended, on the contrary, that the bill solicited by Worcester was the object of a long and minute examination, but to annul the evidence of Walpole it would have been necessary to prove that the commissioners appointed by Parliament had seen a machine in operation, or at least a model, and so far nobody has pretended this to be the case.

† The Count of Sinzendorff, owner of several inundated mines in Bohemia, wanted Papin to go and drain them with his machine; but the unfortunate circumstances in which Germany was placed at that time prevented him from removing. "I should desire extremely, said he, to render my humble services to your excellency, were it not that the ruined state of the country in our neighbourhood, and the uncertainty of the events of the war, warn me that I ought not to leave my family at such a distance, and at a time like this." (*Recueil de diverses pièces, etc., p.* 49.)

tube, with a sheet of water, the level of which is not more than from 25 to 30 feet below, it will fill itself by suction. In adding that, to avoid intermissions in the supply of water, Savery employed a third vessel, which filled with liquid, while the second was emptying, and reciprocally, that the second and third vessel were, *one after the other*, in communication with the boiler, by the assistance of a convenient system of tubes and cocks, I shall have noticed every thing essential in this engineer's machine.

Solomon de Caus' apparatus has been found fault with, for only raising the water while *hot*. This reproach, it must be admitted, has some weight, in reference to economy, but it applies also, to a certain point, to Savery's engine. In this machine in fact, the steam proceeding from the boiler before acting upon the surface of the water of the second, or the third, vessel, is condensed in considerable quantities. Its elasticity does not become efficacious until after the water has acquired a high temperature: therefore when the water begins to rise, it is hot.* Robison said he had ascertained experimentally, that in employing steam as Savery did, at least $\frac{11}{12}$ths is condensed, either by the sides of the second, or third, vessel, or by the water which they contain; even when the pressure is small. In an analogous machine, to avoid the enormous waste of steam, of which I have just spoken, Papin thought of interposing a piston or float, (flotteur.)† This contrivance was not adopted, less, I think, on account of the difficulties in executing it, than on account of very serious defects inseparable from this kind of machine. To raise water to the inconsiderable height of 65 metres, (200 feet;) for example, Savery was obliged to raise the steam of his boiler to six atmospheres; hence, the continual derangements of the joints, hence, also, the melting of the cement, and even dangerous explosions. Moreover, in spite of the title of his work, the machines of this engineer served no useful purpose in the mines. They were only used to distribute water through various parts of the palaces, or of country seats, in parks or in gardens, wherever, in a word, the difference of level to surmount did not exceed some forty feet. With the assistance of the machine proposed by Papin, there is no height, on the contrary, to which water might not be carried, even in using a very low pressure of steam: for this purpose it is only necessary to give a sufficiently large diameter to the cylinder.

To sum up, Savery tried to make use of the elastic power of steam, to

* In fact, merely a thin stratum of hot water is formed by the condensation of the steam, and Savery's engine by no means raises *hot water*, as asserted by M. Arago; a very similar engine to Savery's, has recently been put up in one of the slaughter houses (abattoirs) of Paris to raise water! TRANS.

† Mr. Robert Stuart believes that in introducing a float in the body of the cylinder, Papin's object was not to hinder the condensation of steam. (See a Descriptive history, 2d edit. p. 52.) Papin nevertheless explains himself very clearly upon this subject, and we shall even see by the passage, which I find in page 26, of the work published in 1707, how forcibly this defect struck him:

"I remark that the steam which passes into the pump to drive the water out of it, meets in the machine, (Savery's) cold water which condenses it, and makes it lose the greater part of its force. . . . . It is only after the water is heated that we can expel it . . . . ; to heat the water in this way a great deal of steam must be consumed. It is necessary, therefore, frequently to replenish the boiler with fresh water, and it requires a great deal of time, and of wood to heat it again. But by means of our piston, (flotteur a deux fonds) the steam encounters always the same surface of metal, which soon acquires such great heat that the steam loses little or nothing of its force by the contact."

drive up water in a vertical tube; but Solomon de Caus had done it precisely in the same way, eighty-three years before. Savery filled the vessels in which the steam was afterwards to operate, by suction; but suction was not a new principle in 1698, since the "*abhorrence of a vacuum*" had been very anciently invented to explain it, and because we find elsewhere applications entirely similar to those of the English machinist, in the *Raisons des forces mouvantes;* suction at the most, added very little to the value of the machine, for it increased only by some thirty feet the height to which the liquid would have been raised without its aid. Savery, at length, caused the vacuum which produced the suction, by *condensing the steam;* here the method is important, but Papin had published it long before. The patent granted to Savery is dated 25th July, 1698; the trials of his machine before the Royal Society, took place in the month of June, 1699; the first edition of the Miner's Friend is dated in 1702, thus Papin's titles have a priority of three years, even if setting aside the Acts of Leipsic, we only go as far back as the *Recueil,* in which several memoirs of this machinist are found, for this work was published in 1695. What then is left to Savery? The honor of having first *executed* on rather a large scale, a steam draining machine, and if you please, that of having caused condensation by the affusion of cold water on the outside of the metallic vessel containing the steam. In describing for the first time this ingenious method of producing a vacuum, Papin, in fact, neglected to explain the *different constructions easy to imagine,* (these are his expressions) which *may be employed* to attain this end. During his experiments with a small cylinder, he contented himself, as we have seen with removing the fire.

1705. *Newcomen, Cawley, and Savery.**

The draining machine known to artisans by the name of *Newcomen's engine,* or, the atmospheric engine, was the first which rendered any essential service to art. I will observe indeed, that in a great many places where coal is not dear, it is still in use, and that it has not been found profitable to replace it. This machine, finally, excepting some details in its construction, which I shall notice farther on, *is none other* than the machine proposed in 1690, and 1695, by Papin, and which he tried on a small scale. In both, we remark, in fact, a vertical metallic cylinder closed at the bottom, open at the top, and having a well adjusted piston intended to work through its whole length. In both, the ascending motion of the piston works by the effect of a counter-poise, when the steam can come freely into the lower part of the pump and fill it. In the English machine, as well as in Papin's, as soon as the piston reaches the end of its ascending course, the steam which has forced it there is condensed, and in this way a vacuum is made in the space through which it has just passed, and the atmosphere forces it then to descend. Papin announced that this condensation must be effected *by cold;* and it is by cold that Newcomen, Cawley, and Savery, also get rid of the steam which would counter-balance the atmospheric pressure. *Among many different constructions which may*

* Thomas Newcomen and John Cawley, both lived in the town of Dartmouth, in Devonshire. The first was an iron monger or a black smith, for he is mentioned as exercising both of these trades in the English biographies; the latter was a glazier. Newcomen was a man of some education, and was in correspondence with Hooke, Secretary to the Royal Society, and one of the most ingenious *Savants* of whom England may boast. We are ignorant whether the two associates took an equal part in the various experiments which led to the construction of the first *large* atmospheric engine.

be imagined for this purpose, (this is the expression contained in the *Recueil de pièces*, p. 53,) the English machinists have adopted one, much preferable in a large machine, to that which Papin himself used in the experiments made with his little model. In the place of removing the fire as Papin did, Newcomen, Cawley, and Savery, caused an abundant quantity of cold water to flow into the annular space comprised between the outside of the cylinder and a second cylinder rather larger in size, which enveloped it. The cooling communicated itself in this way gradually to the whole thickness of the metal, and soon reached the steam itself.

Papin's machine, thus modified as to the mode of cooling the aqueous vapor, excited the attention of proprietors of mines in the highest degree, and appeared, from the beginning, to furnish an unhoped for solution of the problem of which the fruitless attempts of Savery had particularly shown the difficulty. Newcomen, and Cawley, solicited a patent. Savery objected that he was already in possession of an exclusive privilege with regard to the means of producing a vacuum by condensing the steam. To avoid all dispute, the patent was taken out in the name, and for the advantage of the three competitors, who in this way attributed to themselves, in the plan borrowed from Papin, the two first the idea of the steam engine with a piston, and the third that of condensation.* At the commencement of the 18th century, the art of constructing large and perfect cylinders, and the art of fitting to them movable pistons, which close them hermetically, had made very little progress. Thus, in the machine made in 1705, to prevent the steam from escaping through the interstices comprised between the surface of the cylinder and the piston the upper surface of this piston was continually covered by a layer of water which penetrated into, and filled all the hollows.

One day while a machine of this description was in operation under the eye of the constructors, they saw, with extreme surprise, the piston descend several times in succession much more rapidly than usual. This rapidity appeared the more strange to them, as the refrigeration produced by the current of cold water which descended along the outside surface of the body of the cylinder, had so far been rather slow in producing the condensation of the steam on the inside. Upon verifying the fact, it was proved that on this occasion, the phenomenon was attributable to an entirely different cause: the piston having accidentally a small hole in it, the cold water which covered it, passed *into the inside of the cylinder itself, in a jet, across the stream*, cooled it, and consequently condensed it faster.

From this period, atmospheric engines were provided with an opening like the mouth of a watering pot; from this proceeded a shower of cold water, which spread in the interior of the cylinder, and there condensed the steam at the moment in which the piston was about to descend. The exterior

* In the arts, as in the sciences, the last comer is supposed to be acquainted with the labors of those who preceded him. All denial in this respect is without value. The publication of the memoirs written by Papin upon the atmospheric engine, being much anterior to the patents granted to Savery and Newcomen, I shall have no motive for investigating whether the English machine is, or is not a copy: according to rule, it is a copy since it is like Papin's machine, and because it followed it. But we know moreover, in this particular instance, that Newcomen was acquainted with the plans of our countryman! It results, in fact, from various notes found among Hooke's papers, that the Dartmouth artist had consulted this famous *Savant* before beginning his experiments, and then, in the confidence of intimacy it was really the French engine which he wanted to construct. (See Robison *A System*, &c. vol. 11, p. 58.)

cooling was in this way suppressed, and the strokes much quicker. This important improvement, like many others which might be cited, was the result of a fortunate accident. I regret very much not being able here to point out which of the three associates it was whose inventive mind saw directly, in the unexpected event of which I have given an account, the principle of an improvement which is still found in the engines of the present time; but tradition gives us no information upon this subject.

[TO BE CONTINUED.]

Notices of the advancement of Mineralogy in 1837, from Berzelius Jahresbericht.

(Continued from Vol. XXIV, page 367.)

In the former report p. 206, I mentioned two of the new minerals analysed by Thomson, one of which was said to consist of 2 (Ca 0 + C 0^2) + (Ba 0+C 0^2) and the other of one atom of sulphate, and two atoms of carbonate of baryta. *Johnston** repeating the analysis, found the former (Ca 0 + C 0^2) + (Ba 0+C 0^2) and the latter Ba 0+C 0^2 or a simple carbonate of baryta. *Thomson*† again repeated the analysis of the former, and although this formula differs from his first, yet it varies from that of Johnston, being represented by the formula (Mn 0 + C 0^2) + (4 Ca 0 + C 0^2) + (4 Ba 0 + C 0^2), or one part carbonate of manganese with four parts each of the carbonates of lime and baryta. The identity of its crystaline form with that formerly given for the same compound, favors the results of Johnston. It will be interesting to see how many of the results of Thomson's analyses presented in my last report, will stand the test of the experiments of other chemists!

Sheppard‡ examined a protophosphate of cerium (Edwardsite) which occurs in Gneiss, in Norwich, Connecticut. It forms crystals, with an oblique rhombic prism as its radical; the small prisms generally present pyramidal terminations. It is hyacinth red; gives a white streak; is translucent—transparent; sp. gr. 4.2—4.6. It is found in crystals from $\frac{1}{6}$ — $\frac{1}{3}$ of an inch in breadth. Before the blow pipe it becomes pearl-gray with a yellowish tint, and fuses on the edges to a transparent glass. Analysis gave:

Protoxide of cerium,	56.53
Phosphoric acid,	26.66
Zirconia,	7.77
Alumina,	4.44
Silica,	3.33
Traces of glucina, magnesia, and oxide of iron,	
	98.73.

The proportion of phosphoric acid to oxide of cerium is represented by (Ce $0)^3$ + (P^2 0^5).

Copper-mica from Goslar was examined by *Borchers*.§ It is a pale, sometimes gold-yellow, artificial mineral product of a metallic splendent lustre, in the form of very thin, micaceous, six sided tables, occurring in an inferior kind of copper, called by the workmen mica-copper, and remains after dissolving the copper in nitric acid. This peculiar product consists of:

* L. & E. Phil. Mag. X, 373.
† Ditto, XI, 45.
‡ Journal für Pract. Chem. XII, 185.
§ Poggend. Annal. XLI, 335.

Oxide of copper,	44.278
" Nickel,	30.612
" Antimony,	25.110

The oxides of copper and nickel together, appear to contain four times as much oxygen as that of antimony.

*Damur** analyzed a vanadiate of lead, the locality of which was unknown. It sits on quartz, forming brownish-yellow warts, which are dark green on their fractured surface, but yield a pale yellow powder. It contains:

Chloride of lead,	8.889
Oxide of lead,	63.725
" Zinc,	6.345
" Copper,	2.960
Vanadic acid,	15.860
Water,	3.800
	101.579

Apjohn† analyzed a mineral from Africa, which occurs in snow-white fibres with silky lustre, about 6 inches in length, and ascertained its composition to be $(Mg\,0 + S\,0^3) + (Al^2\,0^3 + S^3 0^9)$. It is therefore an alum, in which the potassa is replaced by protoxide of manganese.

Von Holger‡ has undertaken to enrich the science of mineralogy with an entirely distinct branch, of which no one would previously have dreamed, viz. with a "Pathology of the mineral kingdom." In order to have a Pathology, minerals should also possess vitality. "No one," says V. Holger, "now views minerals as lifeless bodies, in contradistinction to living, organic beings, but it is believed that they possess life like the latter, although it is of a different kind. They must then exert vital energy, &c." He proceeds from this introduction to the *Diseases* of minerals, which constitute mineral Pathology, and attempts to show that they may be diseased in regard to their composition, their form and their origin. What was said by a philosopher about 2000 years ago still holds good, that nothing is so absurd, but it may at some day be asserted and maintained by the learned!

The present number closes the extracts from Berzelius' Report, for the year 1837, and should it be deemed of sufficient interest to the readers of the Journal, the committee will endeavor to introduce similar notices from the Report of 1838, which is at present in the course of publication in Germany.

Civil Engineering.

On the Mensuration of Excavation and Embankment, upon Canals, Roads, and Rail Roads. By Ellwood Morris, *Civil Engineer.*

On directing the attention to Public Works, one is immediately struck with the vastness of the amount of money expended in Excavation, Embankment and Masonry: forming on the Roads and Rail Roads, usually the chief, and on the canals nearly the only items of outlay. We have the authority of the Chev. de Gerstner, that the 3000 miles of railway this year

* Journ. für Pract. Chemie. XI, 134. † Annal. der Pharmacie, XXII, 272.
‡ Zeitschrift für Physik von Baumgärtner & Ritter, v. Holger, V. 159.

in operation in the United States, cost sixty millions of dollars.* Of which, perhaps, forty millions were laid out in the graduation and masonry alone.

When to this, we add the immense expenditures for similar objects upon the Canals and Roads of the Union, will it be too much to say that near one hundred millions of dollars have been disbursed in the earth works, requisite to reduce the routes to proper levels, and the architectural constructions necessary to pass the streams.

This large amount of work having been done chiefly by contract, and paid for by the cubic yard, or perch, the vast importance of accuracy and uniformity in calculating the contents of Excavation, Embankment, and Masonry solids, must be palpable to all. Unfortunately, great diversity has existed, and still continues to exist, in the modes of mensuration adopted by Engineers; they may, however, in a general way, be divided into two principal methods, and the modifications which flow from them; first, those which depend on arithmetical, and, second, those dependant on geometrical, average.

When we state that neither of these modes is exact, except in a limited number of cases, we merely mention what is well known to every engineer: but which is a reason not the less powerful, to induce us to seek more perfect methods.

The importance of this subject will, we trust, be a sufficient apology for laying before the readers of the Journal of the Franklin Institute a few observations, with the hope of drawing to it the attention of abler minds.†

We are aware, that it is urged by some, that the modes of measurement are immaterial, provided, the values of the unit of measure computed in a particular mode were known, and that mode generally adopted; and this argument would have great force if any single rule or method of mensuration was used in general practice: But whilst on some works the mode of computation uniformly errs in excess, on others it probably errs in deficiency, or, otherwise, according to circumstances; and this brings us back to the importance of a uniform and more exact mode.

The surface of the ground is regarded by the Engineer, as being composed of planes, variously disposed with relation to each other; so that any vertical section, will exhibit a rectilineal figure more or less regular. This supposition, though not strictly correct, is sufficiently accurate for practical purposes, and avoids any necessity of entering into the complex calculations pertaining to warped surfaces.

The usual method of measuring excavation and embankment, is by taking vertical sections, perpendicular to the centre line of the canal or road, and at short distances apart, in which the elevation or depression of numerous points in the ground, above or below the bottom of canal or grade of road, is ascertained by the spirit level and rod, whilst their distances out, right and left, are measured (generally) with a tape line.

These elevations or depressions are commonly called *plus* or *minus cuttings*, or simply *cuttings*, and the distances of the several points from the centre line are denominated shortly *distances out*. The *cuttings* then are ordinates or perpendiculars drawn from the plane of grade or bottom, to intersect the surface of the ground; and the *distances out*, are the horizontal distances of those perpendiculars from the centre line, (measured at right

* See Journal Franklin Institute for September 1839.

† A Treatise on the Mensuration of Excavation and Embankment, from the pen of a Northern Engineer, well able to manage such a subject, was lately announced as being in the press, it has not however (the writer believes) yet been published.

angles) and which, by deduction, give the distances apart of the separate cuttings, or the abscissa of those ordinates.

The details of the operation of *taking the cuttings* require great nicety, but are so well known to practical Engineers as to render unnecessary a description at length. We may, however, mention a general rule which must not be neglected if accurate results are desired; viz: At every change of slope transversely, single cuttings, and distances out, must be taken, and at every longitudinal change, sections of cuttings.

Upon rough ground it is customary to make the lateral distances apart of the cuttings uniformly ten feet, which materially facilitates the subsequent calculations. We may here observe that the cuttings and distances out, are commonly taken in feet and tenths, and the regular stations of one hundred feet, are divided by cross sections (or sections of cuttings) into shorter lengths if the ground requires, as it almost always does.

Some Engineers have suggested the division, and we believe some have had their rods and tapes divided, into yards and decimals; and some retaining the rod and tape as usual, have made their regular stations fifty four feet, and have spaced their cross sections where they required to be nearer, so that their distances apart should be some aliquot part of 54 feet. These methods, though they somewhat expedite the office work where the quantities are ascertained by the process of arithmetical average, are not, however, generally adopted by the profession: A foot being usually the unit of lineal measure, a hundred feet a regular station, and the cubic yard the unit of the solidity of excavations and embankments.

The isometrical diagram, fig. 1, Plate 1, represents a regular station of embankment on irregular ground, with an intermediate cross section at 50 feet or midway. Base or width of road surface = 30 feet, slopes 2 to 1, *a*, *b*, *c*, *d*, *e*, *f*, and *g*, are cuttings, *minus cuttings*, in this case: 1: 2: and 3: are the *sections of cuttings*, or cross sections. C, C, is the centre line.

Earth work on Roads and Canals is usually laid off in divisions called *sections* of half a mile or more in length, and when a sufficient number of transverse sections of the ground have been obtained, or technically when the "*cuttings are taken*," the transverse profiles or cross sections are drawn upon paper, their areas calculated, and the solid contents of the excavations and embankments computed; generally by one of two rules, viz:

No. 1: *By Arithmetical Average.*—Multiply the sum of the end areas by their distance apart, and divide the product by 6 and by 9; the result will give, *approximately*, the number of cubic yards in the given length of excavation or embankment.

No. 2: *By Geometrical Average.*—Multiply the sum of the end areas, and the square root of their product, by the distance apart, and divide the product by 9 and by 9. The result will be, *nearly*, the number of cubic yards in the given length of excavation or embankment.

Of these rules, No. 1: gives a result always in excess, except when the excavation or embankment solid, happens to be a prism or cylinder, or when the sums of the right and left distances out, are the same for both the end areas used.

And, No. 2: though accurate when applied to prisms, cylinders, pyramids and cones, or their frustra, fails on application to the prismoid or wedge, as well as to embankment or excavation solids, on irregular ground, where the difference is great between the areas of adjacent transverse sections.

Such is a brief sketch of the modes in common use for measuring excava-

tion and embankment on roads and canals; of which we may observe, that the method, (No. 1,) and all others founded upon the same principles, necessarily lead to errors, often of magnitude, and particularly in deducing "deficient embankment," as is very well shown by Mr. Macneill, in the introduction to his excavation and embankment tables published in 1833. It is true, that Engineers in this country would seldom fail to arrive at much closer results than Mr. Macneill has instanced; because, being well aware, that this very convenient rule (No. 1,) always gives results which are in excess in some ratio to the difference of any two areas averaged, they take care to place their cross sections so near together that this difference may be small, and consequently by closely pursuing this course are enabled to reach results proportionally more exact. Indeed, the writer has often known sections of cuttings on sidehill, to be taken but 10 feet apart longitudinally, and in some extraordinary cases amongst rocks even at a less distance.

The rule No. 2: though not liable to so many, nor such strong objections, is still obnoxious to some: and where greater, indeed almost precise, accuracy is attainable without much more labour, we cannot but think it highly desirable, and accordingly propose to develope a method much superior, as it appears to us. But before doing so, the writer distinctly disclaims any attempt at novelty, as to the principles employed; for they have been long known to those versed in mensuration, and have also been applied to the matter in hand by the eminent Engineer before alluded to (J. Macneill, Esq., C. E. &c.,) in his publication in 1833. It is believed, however, that as a *general process*, the mode about to be laid down has not yet been used on any work.

Upon the general supposition that any given length of excavation or embankment is a solid bounded laterally by plane surfaces, and terminated at both ends by transverse sections, or planes, perpendicular to the centre or guiding line of the excavation or embankment; the contents of that solid may be accurately computed by aid of the "prismoidal formula," used by Mr. Macneill, who gives a very good demonstration of it as applied directly to one of the solids under consideration. Mr. Macneill's tables, though carefully made out, and undoubtedly useful in a level country, are unfortunately not of very ready application to common cases, owing to the variable transverse figure of the ground not having been (and which indeed is scarcely capable of being) taken into the account in the tabular arrangement employed by that distinguished practical writer.

The "Prismoidal Formula" referred to, is as follows:

Parallel sections each perpendicular to the guiding line of the excavation or embankment.

Let b = The area of the base, or of a cross section at one end of a given length of excavation or embankment.

" t = The area of the top, or other end section.

" m = The area of a section midway between the two, and deduced from them.

" h = The height of the solid, or perp. distance between the end sections.

" = S The solidity.

Then the General Formula $= \overline{b + 4\,m + t} \times \frac{1}{6}\,h = \mathrm{S}$.

This is the rule for the capacity of a prismoid, demonstrated in almost every treatise on mensuration. And it is also the General Formula for the mensuration of all solids, whose bases and tops, or edges, lie in parallel

planes, and whose sides are bounded either by planes or right lines; and from it can be directly deduced the common rules for the solidity of prisms, &c., as will be shown hereafter.

*It applies to a prism or cylinder as a prismoid, (so to speak) of which the two end sections are equal; to a cone or pyramid as a similar solid, one of whose end sections is nothing; and for the same reason it is applicable to the wedge. As the full demonstration of this remarkable property would occupy much space, we prefer the inverse method of deducing from the General Formula, the common rules for the solidity of prisms, pyramids, &c., the truth of which have been already proven by the writers on mensuration; this will be a proof of the general rule, perhaps quite as satisfactory to the reader, and will, at least, have the recommendation of brevity.

General Formula $= \overline{b + 4m + t} \times \frac{1}{6} h = S.$

1. *Prisms or Cylinders.*

Here $b = m$, or $4m = 4$ b, and $t = b$, substituting these values, Gen For: becomes $\overline{b + 4b + b} \times \frac{1}{6} h = S.$ or $6b \times \frac{1}{6} h = S$, or finally $b \times h = S$, which is the common rule, usually expressed thus.

"Multiply the area of the base by the height of the prism, and the product will give the solid content."

By figures referring to the diagram, fig. 2, Plate 1.

By General Formula.		By Common Rule.	
$10 \times 8 =$	$80 = b$	$10 \times 8 =$	$80 = b$
$10 \times 8 \times 4 =$	$320 = 4m$		$48 = h$
$10 \times 8 =$	$80 = t$		
	480	$b \times h =$	$3840 = S$
	$8 = \frac{1}{6} h$		
	$3840 = S$		

2. *Pyramids and Cones.*

Here $t = o$, $m = \frac{1}{4} b$, or $4m = b$, substituting these values the Gen: For: becomes $\overline{b + b + o} \times \frac{1}{6} h = S.$ or $2b \times \frac{1}{6} h = S.$ or finally $b \times \frac{1}{3} h = S.$ which is the common rule usually stated in words thus,

"Multiply the area of the base by one third of the height, and the product will be the solid content."

By figures referring to the diagram, fig. 3, plate 1.

By General Formula.		By Common Rule.	
$10 \times 8 =$	$80 = b$	$10 \times 8 =$	$80 = b$
$5 \times 4 \times 4 =$	$80 = 4m$		$16 = \frac{1}{5} h$
$0 \times 0 =$	$0 = t$		
	160		$1280 = S$
	$8 = \frac{1}{6} h$		
	$1280 = S$		

* This subject is noticed by (I believe) Sir George Head, in a work on England, speaking of a system of Education.

3. *The Wedge.*

Here let e = length of the edge, l = length of the back, and d = depth or thickness of the back.

Then in the general formula, $t = o$. $b = l \times d$, $m = \frac{l+e}{2} \times \frac{d}{2}$ or 4 $m = \overline{l+e} \times d$, substituting these values, general formula becomes $\overline{l \times d + \overline{l+e} \times d} \times \frac{1}{6} h = S$. Or $\overline{l \times d + \overline{l \times d + e} \times d} \times \frac{1}{6} h = S$. Or, finally $\overline{2l+e} \times d \times \frac{1}{6} h = S$. which is the common rule usually expressed thus,

"To the length of the edge, add twice the length of the back; multiply this sum by the breadth (or thickness) of the back, and then by one sixth of the height of the wedge; the product will be the solid content."

By figures see the diagram, fig. 4, plate 1.

By General Formula.	By Common Rule.
$10 \times 8 = 80 = b$	$10 \times 2 + 30 = 50 = 2l + e$
$20 \times 4 \times 4 = 320 = 4m$	$8 = d$
$0 \times 30 = 0 = t$	400
400	$8 = \frac{1}{6} h$
$8 = \frac{1}{6} h$	3200 = S
3200 = S	

To the frustra of either of the above solids, the general formula is equally applicable, to prove which we observe, that the frustrum of a prism is still a prism, and the frustrum of a wedge is a prismoid; it only remains then to show the application to

4. *The Frustrum of a Pyramid.*

Here, for the sake of simplifying the demonstration, suppose the frustrum to be of a pyramid having a square for its base. Let a = a side of the base of the frustrum, and c = a side of the top. Then in the general formula $b = a^2$ $t = c^2$ and $m = \frac{a+c}{2} \times \frac{a+c}{2}$ or $m = \frac{\overline{a+c}^2}{4}$ hence $4\,m = \overline{a+c}^2 = a^2 + 2ac + c^2$. Substituting these values the general formula becomes $\overline{a^2 + a^2 + 2ac + c^2 + c^2} \times \frac{1}{6} h = S$. or $\overline{2a^2 + 2ac + 2c^2} \times \frac{1}{6} h = S$. or $a^2 + ac + c^2 \times \frac{1}{3} h = S$.

But $ac = \sqrt{a^2 \times c^2}$ substituting which the formula becomes $\overline{a^2 + \sqrt{a^2 \times c^2} + c^2} \times \frac{1}{3} h = S$. which is the common rule usually expressed thus,

"The sum of the areas of the ends and the square root of their product, multiplied by one-third of the height (or perpendicular distance between the ends) gives the solidity of the frustrum."

What is true of frustra of pyramids is also true of those of cones, though, owing to the properties of the circle, the rule for the solidity of conic frustra is generally differently stated: it will be observed that the common rule above deduced for pyramidal frustra is identical with rule No. 2, sometimes used to find the contents of excavations and embankments.

By figures see the diagram, fig. 5, plate I.

By General Formula.		By Common Rule.	
$20\times20=$	$400=b$	$20\times20=$	$400=a^2$
$16\times16\times4=$	$1024=4m$	$\sqrt{400\times144}=$	$240=\sqrt{a^2\times c^2}$
$12\times12=$	$144=t$	$12\times12=$	$144=c^2$
	1568		784
	$8=\frac{1}{6}h$		$16=\frac{1}{3}h$
	12544= S		12544= S

Now there is no excavation or embankment solid such as we have supposed, that cannot be divided into prisms, prismoids, pyramids, or wedges, or some combination of them, having a common length or height, equal to the distance between the end areas or cross sections. And the height or length being common to all, it will be evident on reflection, that if a given portion of excavation or embankment be composed of any number of the solids named, the area of one end section will equal the sum of the areas of the bases or tops of those solids, the other end area the sum of their tops or bases, and the area of the mid-section will equal the sum of the areas of their middle sections; and, hence, if (as has been proved) the capacities of the separate solids are reducible to one general rule, the solidity of a whole body composed of such solids, and having the height as one common dimension, may therefore be computed by the same rule.

The general process, then, the adoption of which we suggest as a valuable succedaneum to those in common use, will be to compute by the general formula from the sections usually taken in the field, in the following manner: Draw the sections in a book, leaving between each two space enough for the middle section, which will be subsequently deduced from those drawn; on each left hand page should be placed either three sections, (including the mid-section) or some multiple of three, depending on the character of the ground, and the size of the leaf; the right hand page being left open to record the calculations upon. The scale we would recommend to be twenty feet to the inch.

To prevent misapprehension, we will here observe, that in speaking of excavation or embankment, the centre line is always supposed to be a tangent, that being the universal presumption, in practical calculations; although upon curves, owing to the convergence of the cross sections, (they being taken on the radii,) this hypothesis is not exact, and consequently occasions some error, not often, however, of much importance, though cases will sometimes arise (where the primary angle of deflection is unusually large), that ought to receive correction for curvature.

Though not absolutely indispensable, it will be found convenient in using the prismoidal method of calculation, as well as conducive both to expedition and accuracy, to observe the following rules in "*taking the cuttings*," as far as the character of the surface may admit, viz:

1. On sidehill, at each section of cuttings where the work runs partly in filling, and partly in cutting, ascertain the point where grade or bottom strikes ground surface.

2. On every transverse section take a cutting at both edges of the road, or, at the distance out right and left of one half the base.

3. Always take a cross section, whenever either edge of the road or base passes from excavation to embankment, or vice versa.

4. On sidehill, if the ground admits, take the cuttings (not otherwise provided for) uniformly at ten feet apart.

5. Wherever the ground admits, so place the cross sections as to be at some decimal division of 100 feet apart, as 10, 20, &c.

Excavation and embankment solids, naturally divide themselves into three classes or cases, with modifications, and under one or another of these cases or their modifications, will fall nearly every kind of ground; though on a very intricate surface, such as a rocky hillside, cases may arise, requiring additive or deductive solids, but the Engineer will find little difficulty in managing such, without violating, or interfering with, the general process.

Case 1. *Prisms.*

Embankment or excavation, either on level ground, or on ground inclined transversely, and level longitudinally, at the same distance out.

Modification 1: all excavation, or all embankment. *Modification* 2: both filling and cutting.

Case 2. *Prisms, Prismoids, and Pyramids.*

Embankment or excavation, on ground inclined longitudinally in one plane, and level transversely.

Modification 1: all excavation, or all embankment. *Modification* 2: passage from excavation to embankment, or the reverse.

The above two cases do not often exist in practice, that following being of he most general occurrence.

Case 3. *Prisms, Prismoids, Pyramids, & Wedges, or a combination of them.*

Excavation or embankment on ground inclined *both* longitudinally and transversely.

Modification 1: all excavation, or all embankment. *Modification* 2: cutting and filling both. *Modification* 3: passage from cutting and filling to either cutting or filling. *Modification* 4, complete passage from excavation to embankment on sidelong ground.

The General Formula admits of a modification, more convenient for use in computing excavation and embankment. It is as follows:

$\frac{b+4m+t}{6} \times h = S.$ in lieu of $\overline{b+4m+t} \times \frac{1}{6} h = S$; this modification we shall employ; and now proceed to give examples in figures of each case, but it may be as well previously, to make some remarks relative to deducing the middle section between any two which have been taken in the field, and sketched in the section book.

To average for the cuttings of the middle section, commence either at centre or at grade, if there be a grade point upon the cross section, and having regard to the inclination of the ground, proceed each way, averaging the cuttings as they occur, for a corresponding cutting of the middle section, and their distances out, or rather their distances apart, for a corresponding distance apart; and if there be more cuttings in one section than in the other, the surplus cuttings (of the same kind) on each side, all average with the *outer* cutting on that side, and their distances apart divided by two (or averaged with 0,) give the corresponding distances of the cuttings which answer to them upon the mid-section. But the averages may be made in any other way demanded by the transverse slopes of the surface, provided all the cuttings are used, and that lines drawn to join any two cuttings averaged, do neither meet between the end sections nor cross. In the mid-

section will always appear the same number of cuttings as are contained in that end section which has the most; and its correctness admits of verification thus,

1. $\frac{1}{2}$ sum of distances between the extreme cuttings of the end sections, equals the distance between the extreme cuttings of the mid-section. This proves it horizontally: to verify it vertically,

2. Where the number of cuttings of both kinds is the same in each end section, $\frac{1}{2}$ sum of all the cuttings of the end sections, equals the sum of all the cuttings of the middle section.

3. Where the number of cuttings in the end sections is different, to prove the cuttings of excavation, $\frac{1}{2}$ sum of the cuttings of the end sections, equals the sum of the cuttings of the mid-section; *minus*, least outer cutting left of centre multiplied by $\frac{1}{2}$ the difference in the number of cuttings in the end sections on the left; *plus*, least outer cutting right of centre multiplied by the difference in the number of cuttings on the right.

Though this last rule is long in words, it is short in practice, and of course only refers to the excavation or plus cuttings in proving excavation, whilst the same process applied to the minus cuttings will verify the embankment of the middle section.

The exemplifications which will be given apply to the graduation of a road, or rail road, but the principles apply equally to a canal, as the tow path and berm banks above bottom are constant quantities.

In all the following examples the slopes are considered to be the same on both sides of the centre, which is supposed to divide equally the surface of grade, or the base as it will be called. The sections numbered 1: and 3: will uniformly be presumed to be those taken in the field, whilst No. 2: will represent the middle section deduced from the end sections, 1: and 3: the distance between which, will, for convenience, be assumed at 30 feet in every case. Excavations, as to figure, are merely embankments inverted, and hence, as a matter of course, the same principles apply to both.

In all the examples, the results obtained by rules No. 1 and 2, will also be set down for the sake of exhibiting how great in some cases the differences are: the base will be assumed at 30 feet, the slopes at 2 to 1, and C, C, will represent the centre line of the road.

Example of Case 1: *Modification* 1: *fig.* 6, *plate* 1.

$h = 30$.

	Multipliers.		Areas.	C. Yds.
1.	$\frac{30+54}{2} \times 6$ . .	=	252	
2.	$\frac{30+54}{2} \times 6 \times 4$.	=	1008	
3.	$\frac{30+54}{2} \times 6$ . .	=	252	
			6)1512	
		30 ×	252	= 280
	By Rule No. 1			= 280
	By Rule No. 2			= 280

Example of Case 1: *Modification* 2: *fig.* 7, *plate* 1.

Embankment. Multipliers	Areas.	C. Yds.	Excavation. Multipliers.	Areas.	C. Yds.
1. 15×4 =	60		15×2 =	30	
2. $15 \times 4 \times 4$ =	240		$15 \times 2 \times 4$ =	120	
3. 15×4 =	60		15×2 =	30	
6)	360		6)	180	
$30 \times$	60 =	$66\frac{2}{3}$	$30 \times$	30 =	$33\frac{1}{3}$
By Rule No. 1,	=	$66\frac{2}{3}$	By Rule No. 1,	=	$33\frac{1}{3}$
By Rule No. 2,	=	$66\frac{2}{3}$	By Rule No. 2,	=	$33\frac{1}{3}$

Example of Case 2: *Modification* 1: *fig.* 8, *plate* I.

Multipliers.	Areas.	C. Yds.
1. $\frac{30+54}{2} \times 6$ =	252	
2. $\frac{30+46}{2} \times 4 \times 4$ =	608	
3. $\frac{30+38}{2} \times 2$ =	68	
6)	928	
$30 \times$	$154\frac{2}{3}$ =	171.8
By Rule No. 1,	=	177.8
By Rule No. 2,	=	167.0

Example of Case 2: *Modification* 2: *fig.* 9, *plate* II.

Multipliers.	Areas.	C. Yds.
$\frac{30+62}{2} \times 8$ =	368	
$\frac{30+46}{2} \times 4 \times 4$ =	608	
0×15 =	0	
6)	976	
$30 \times$	$162\frac{2}{3}$ =	180.7
By Rule No. 1	=	204.4
By Rule No. 2,	=	136.5

Example of Case 3: *Modification* 1: *fig.* 10, *plate* II.

Multipliers.	Areas.	C. Yds.
Add.		
1. $37 \times 14 = 518$		
$11 \times 10 = 110$		
$18 \times 5 = 90$		
$13 \times 6 = 78$		
Deduct. 796		
$\overline{16}^2 + \overline{4}^2 = 272$		
524 =	524	
Carried forward	524	

	Brought forward	524	
	Add.		
	17.5×10.5=183.75		
	15. ×28.5=427.50		
2.	23. × 6. =138.		
	19. × 5.5=104.50		
	7. ×14. = 98.		
	Deduct. 951.75		
	$\overline{18}^2+\overline{5}^2$=349.		
	Mult. by 4, 602.75	= 2411	
	Add.		
	19×21=399.		
	16×20=320.		
3.	12×14=168.		
	10×12=120.		
	8×15=120.		
	Deduct. 1127.		
	$\overline{20}^2+\overline{6}^2$=436.		
	691	= 691	
		6) 3626	
		30× $604\frac{1}{3}$=	671.5
	By Rule No. 1,	=	675.0
	By Rule No. 2,	=	672.9

Example of Case 3: *Modification* 2: *fig.* 11, *plate* III.

	Excavation. Multipliers.	Areas.	Embankment. Multipliers.	Areas.
	5× 1= 5		16×7=112	
1.	4×10= 40		6×5= 30	
	8×25=200		Dedt. 142	
	Dedt. 245		$\overline{8}^2$= 64	
	$\overline{10}^2$=100		78	= 78
	145	= 145		
	4.5× 1.5= 6.75		11.5×5.5= 63.25	
	5. × 7. = 35.		12.5×4. = 50.	
2.	10.5×17.5=183.75		10.5×3. = 31.5	
	13.5×11. =148.5		7.5×3. = 22.5	
	Dedt. 374.		14. ×6. = 84.	
	$\overline{13}^2$=169.		8.5×2.5= 21.25	
	4×205.	= 820	Dedt. 372.5	
			$\overline{11}^2$=121.	
			4×151.5	= 606
	Carrried over	965	Carried over	684

	Brought over	965		Brought over	684
	4× 2= 8			15×11=165	
3.	4× 6= 24			17× 8=136	
	13×10=130			13× 6= 78	
	17×22=374			7× 6= 42	
				12× 5= 60	
	Dedt. 536			7× 2= 14	
	$\overline{16}^2$=256			Dedt. 495	
	280	= 280		$\overline{14}^2$=196	
		6) 1245		299	= 299
	Mean Area=207.5				6) 983
				Mean Area=	$163\frac{5}{6}$

Excavation.	C. Yds.	Embankment.	C. Yds.
Mean Area	207.5×30=230.6	Mean Area	$163\frac{5}{6}$×30=182.
By Rule No. 1,	=236.1	By Rule No. 1,	=209.4
By Rule No. 2,	=232.0	By Rule No. 2,	=196.6

Example of Case 3: *Modification* 3: *fig.* 12, *plate* IV.

	Embankment.		Excavation.	
	Multipliers.	Areas.	Multipliers.	Areas.
	15×31=465			
	12×10=120			
1.	11×10=110			
	9× 4= 36		Excavation=	0
	6× 6= 36			
	2× 5= 10			
	Dedt. 777			
	$\overline{18}^2$=324			
	453	= 453		
	5.5×12.5=193.75		5. × 1. = 5.	
	11. × 5. = 55.		3. × 4. = 12.	
2.	10.5× 5. = 52 5		5.5× 3. = 16.5	
	9.5× 2. = 19.		10.5×10.5=110.25	
	7. ×13. = 91.		12. ×10. =120.	
	5. × 2.5= 12.5			
	Dedt. 423.75		Dedt. 263.75	
	$\overline{14}^2$=196.		$\overline{10}^2$=100.	
	4×227.75 =	911	4×163.75 =	655
	Carried forward	1364	Carried forward	655

	Brought forward	1364		Brought forward	655
3.	8×20=160			5× 4= 20	
	3× 5= 15			6× 8= 48	
				11× 6= 66	
	Dedt. 175			21×21=441	
	$\overline{10}^2$ =100			24×20=480	
	75	= 75		Dedt. 1055	
				$\overline{20}^2$ = 400	
				655	= 655
		6)1439			6)1310
		Mean Area= $239\frac{5}{6}$			Mean Area= $218\frac{1}{3}$

Embankment.	C. Yds.	Excavation.	C. Yds.
Mean Area,	$239\frac{5}{6}\times30$=266.5	Mean Area,	$218\frac{1}{3}\times30$=242.6
By Rule No. 1,	=293.3	By Rule No. 1,	=364.
By Rule No. 2,	=263.8	By Rule No. 2,	=242.6

Example of Case 3: *Modification* 4: *fig.* 13, *plate* III.

Excavation.			Embankment.	
	Multipliers.	Areas.	Multipliers.	Areas.
			11.5×10=115.	
			10.5×10=105.	
			9. × 4= 36.	
1.	Excavation=	0	7.5×10= 75.	
			6.5× 5= 32.5	
			6. × 5= 30.	
			5. × 5= 25.	
			5. × 2= 10.	
			Dedt. 428.5	
			$\overline{12}^2$ =144.	
			284.5	= 284. 5
	2.5× 1. = 2.5		11.5×2. 5= 28.75	
	3.5× 2.5= 8.75		10.5×2. 5= 26.25	
2.	5.5× 2.5= 13.75		9. ×1. = 9.	
	9. × 5. = 45.		7.5×2. 5= 18.75	
	12. × 2.5= 30.		6.5×1.25= 8.125	
	10.5×18. =189.		3. ×2. 5= 7.50	
			2.5×2. 5= 6.25	
	Dedt. 289.		1. ×2. 5= 2.50	
	$\overline{9}^2$ = 81.		Dedt. 107.125	
			$\overline{6}^2$ = 36.	
	4×208. =	832	4× 71.125 =	284. 5
	Carried over	832	Carried over	569

	Brought over	832		Brought over	569
	5× 2= 10				
	7× 5= 35				
3.	11× 5= 55				
	18×10=180				
	24× 5=120			Embankment=	0
	21×36=756				
	Dedt. 1156				
	$\frac{18^2}{2}$= 324				
	832	= 832			
		6)1664			6) 569
		Mean Area= $277\frac{1}{3}$			Mean Area= 94.83

Excavation.	C. Yds.	Embankment.	C. Yds.
Mean Area,	$277\frac{1}{3}\times30$=308.1	Mean Area,	94.83×30=105.4
By Rule No. 1,	=462.2	By Rule No. 1,	=158.
By Rule No. 2,	=308.1	By Rule No. 2,	=105.4

Objections may possibly be urged against the hypothetical generation of intermediate ground by means of middle sections, and it is difficult to free this subject wholly from exception; but with a given number of transverse sections taken in the field, if close attention is paid to the inclination of the ground as developed by the end sections, and occasionally where it is very complex, if the figures are simplified by introducing additive or deductive solids, we have not yet met with any other practical method, giving results equally satisfactory.

Various expedients are known to engineers for facilitating the computation of the areas of cross sections, to attempt an account of which, though it might be interesting to students, would prolong this paper to an inconvenient length.

The above examples embrace, as we have stated, specimens of the principal varieties of excavation and embankment; and a little attention to the calculations and the modes of deducing the middle sections between those usually taken in the field, will enable any one to apply the "Prismoidal Process" to the mensuration of earth work upon canals, roads or railroads. When the mean areas are computed, it will be much more expeditious to get out the cubic yards from a table of cubic yards previously made out (supposing the stations regularly 100 feet,) for each foot and tenth of mean area, from 0.1 up to the largest which commonly occur: such or similar tables in manuscript are in the possession of many engineers, but those who have them not can in a few days construct a set by simple addition, and verify them by observing how the cubic yards for the preliminary areas of the first hundred, are subsequently repeated in the same decimal place.

Indeed, Mr. Macneill's tables (if extended to tenths of feet) might be used; by constructing a supplemental set to show by inspection the height or centre cutting in level ground, of two sections with the given base and slopes, to be respectively equivalent in area, to the end sections of any given length of excavation or embankment; or these heights could be ascertained by the aid of an ingenious formula given by Mr. Macneill, and being found might then be wrought with in entering the tables according to the directions laid down: either of these proceedings, by determining a true mean cut-

Fig. 1.

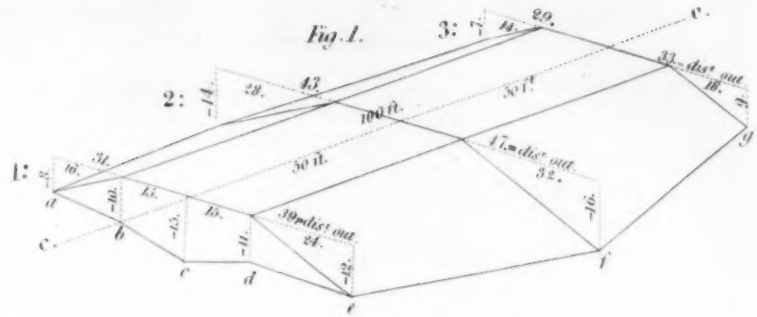


Fig. 2.

Fig. 3.

Fig. 6.

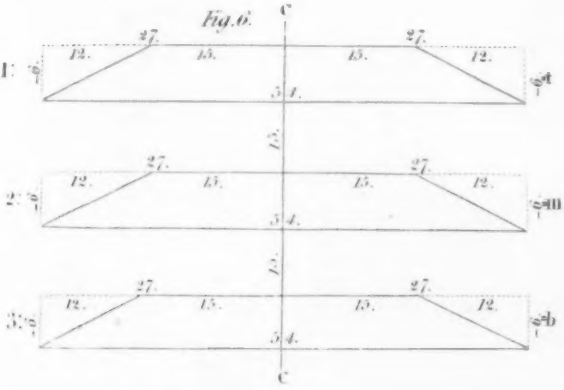


Fig. 4.

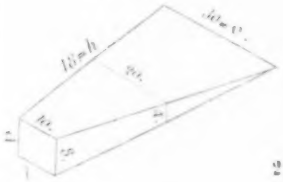


Fig. 7.

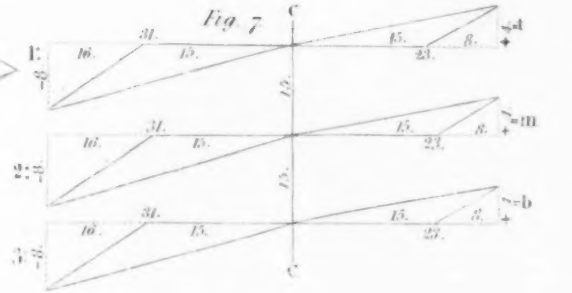


Fig. 5.

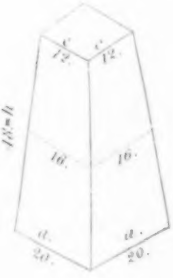
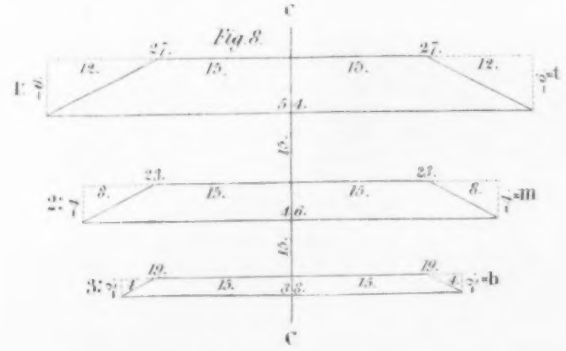


Fig. 8.



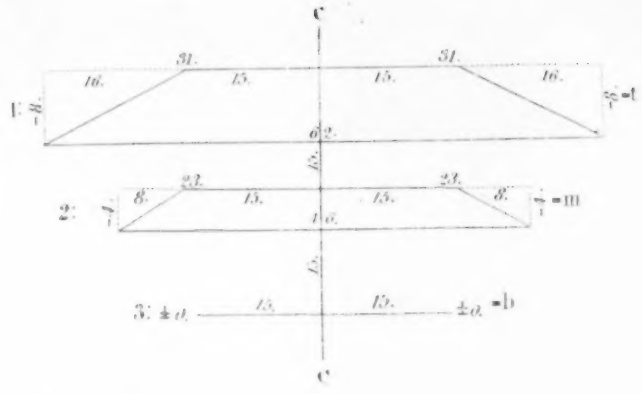

c
31.
31.
16.
15.
15.
16.
1: 8/1
32.
=I
6
2.
5.
23.
23.
2: 4/1
8.
15.
15.
8.
4/1
=III
16.
5.
3: ±0.
15.
15.
±0.
=b
c

Fig. 10.

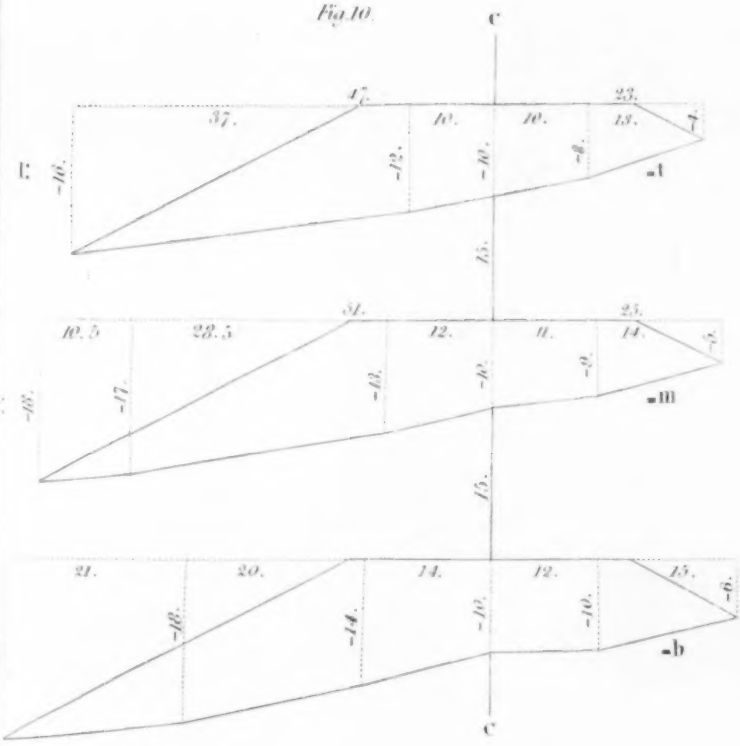

c
47.
23.
37.
10.
10.
13.
7
I:
-16.
-12.
-10.
-8.
=I
15.
51.
25.
10.5
22.5
12.
11.
14.
7
-18.
-17.
-13.
-10.
-9.
=III
15.
21.
20.
14.
12.
15.
-6.
-18.
-14.
-12.
-10.
=b
c

Fig. II.

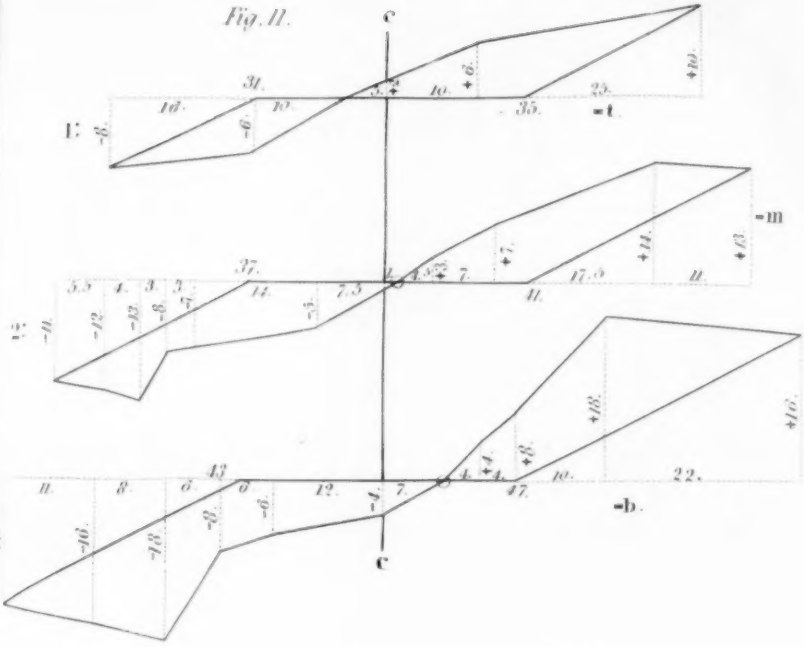


Fig. 13.

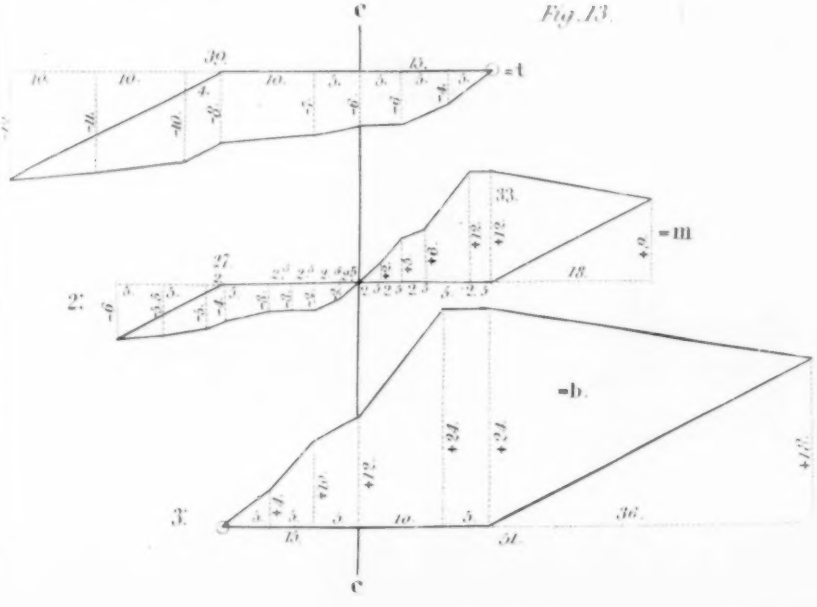
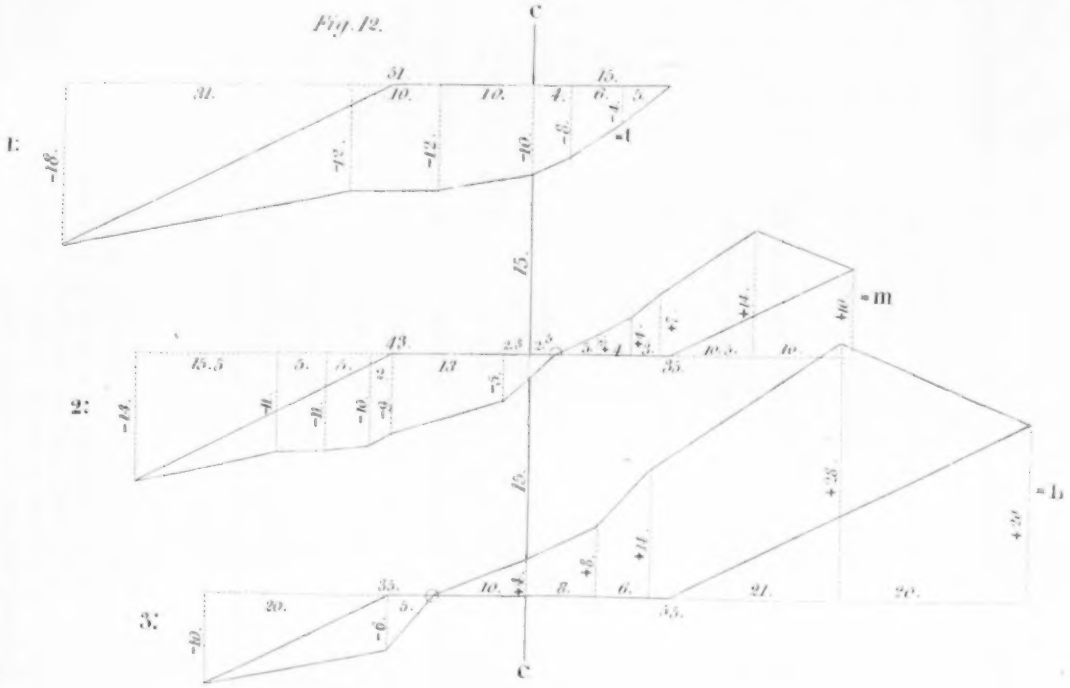


Fig. 12.



ting at each end, would obviate the necessity of a middle section, but neither, it is believed, would be altogether as satisfactory.

We desire to be understood as suggesting the application of the preceding process only to those exact calculations, required by the *Final Estimates* of sections; for running estimates or those on lines of location, less accurate but more speedy methods will answer every purpose.

Oldtown, Md., November 20th, 1839.

TO THE EDITOR OF THE JOURNAL OF THE FRANKLIN INSTITUTE.

In the Railway Magazine, (London,) for August, 1839, I observed a formula for calculating the area of a cross section of excavation in, or embankment on, sloping ground. I shall feel indebted to any of your correspondents who will furnish me with a solution by which its correctness may be ascertained.

Having the bottom width given, if excavation, (or top width, if embankment,) = E; the depth at $\frac{E}{2}$ from the centre, on each side, = D and d respectively; and the ratio of the side slopes = r; the following is the formula given,

$$\frac{E\,r\,d^2}{2E+2r\,(D-d)}+\frac{E\,r\,D^2}{2E-2r\,(D-d)}+\frac{E\,(D+d)}{2}=\text{area.}$$

Respectfully, &c.

J. M. H.

Philadelphia, Jan. 1, 1840.

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*Telford Premiums to be awarded by the Institution of Civil Engineers of London.**

The Committee on Publications of the Franklin Institute having received the following circular from the Institution of Civil Engineers, lay it with pleasure before the readers of the Journal, believing, that to many of them it will be a subject of interest. COM. PUBLICATIONS.

Institution of Civil Engineers, established 1818, *incorporated* 1828.

The Council of the Institution of Civil Engineers give notice that they will award, during the ensuing session, Telford Premiums to Communications of adequate merit on the following subjects:

1. The nature and properties of steam, especially with reference to the quantity of water in a given bulk of steam in free communication with water at different temperatures.

2. An account and drawings of the original construction and present state of the Plymouth breakwater.

3. The ratio, from actual experiment, of the velocity, load, and power, of locomotive engines on railways.

1st. Upon levels.

2nd. Upon inclined planes.

4. Drawings and description of the outfall of the King's scholars' pond sewer, and of other principal outfalls of the Westminster sewage; also, the

*The premiums of this Institution are awarded to Foreigners as well as Englishmen.

inclination, dimensions, and forms, of the sewers, and the observed velocities of water in them.

5. Drawings and descriptions of the sewage under the commission for Regent street, especially of the outfall at Scotland yard.

6. Drawings and description of the best machine for describing the profile of a road, and also for measuring the traction of different roads.

7. The alterations and improvements in Blackfriar's bridge.

8. The explosion of steam boilers.—Especially a record of facts connected with any explosions which have taken place; also, a description, drawings, and details, of the boiler, both before and after the explosion.

9. Drawings, sections, and descriptions, of iron steam vessels.

10. The comparative advantages of iron and wood as employed in the construction of steam vessels.

11. The comparative advantages and disadvantages of hot and cold blast in the manufacture of iron, with statements of the quality and quantity of materials employed, and produce thereof.

12. The causes of, and means of preventing, the changes in texture and composition which cast iron occasionally undergoes when in continued contact with sea water.

13. The properties and chemical constitution of the various kinds of coal.

14. A memoir of Sir Hugh Middleton, with an account of his works.

15. A memoir of Arthur Woolf, with an account of his works.

16. An account of the various methods lately employed for preserving timber from dry rot, and other sources of decay.

17. On the best gauge for the width of railways, with the result of the experience furnished by existing railways.

The communications must be forwarded to the House of the Institution, No. 25, Great George street, Westminster, on or before the 31st of March, 1840.

It is not the wish of the Council to confine the Telford Premiums to communications on the above subjects; other communications of distinguished merit and peculiarly deserving some mark of distinction will be rewarded.

Copies of this paper, and any farther information, may be obtained on application to the Secretaries.

THOMAS WEBSTER, } Secretaries.
CHARLES MANBY, }

25, *Great George street, Westminster, June* 25, 1839.

Telford Premiums.

The Council of the Institution of Civil Engineers have awarded the following Telford Premiums:—

A Telford medal in silver and twenty guineas to John Edward Jones, for his description, plan and drawings of the sewage of Westminster.

A Telford medal in silver to Charles Hood, for his paper on warming and ventilating buildings.

A Telford medal in silver to Charles Wye Williams, for his paper on the properties and application of turf and turf coke.

A Telford medal in silver to Edward Woods, for his paper on the forms of locomotive engines.

A Telford medal in bronze, and books suitably bound and inscribed, of the value of three guineas, to Lieut. Frederick Pollock, Madras Engineers, for his description and drawings of the Coffre Dam of Westminster bridge.

A Telford medal in bronze, and books suitably bound and inscribed, of the value of three guineas, to R. W. Mylne, for his communication on the well sunk by the New River Company at their reservoir in the Hampstead Road.

A Telford medal in bronze, and books suitably bound and inscribed, of the value of three guineas, to John Buldry Redman, for his description and drawings of Bow bridge.

The Council would take this opportunity of calling attention to the importance of making the Institution the depository of detailed drawings, descriptions, and models, of works and machinery actually executed; also of professional books, papers, and reports, which are of little value to the individual, but which, when collected and arranged in one place, would be of inestimable value to the profession. They trust that all who have such records at their disposal will consider the great service which may thus be rendered to the cause of the advancement of professional knowledge.

Bibliographical Notices.

Report on Education in Europe, to the Trustees of the Girard College for Orphans; by Alex. Dallas Bache, L. L. D., *President of the College.*

It is probably known to most of the readers of this Journal, that soon after the appointment of Professor Bache to the Presidency of the Girard College, he was deputed by the Trustees to visit those parts of Europe in which it was known that education had made the greatest progress, for the purpose not only of making the system of instruction therein pursued, better known to his countrymen, but especially that he might have more abundant materials and a broader foundation for a plan of education for the magnificent Institution over which he is to preside. He was engaged about two years in his visitations and inquiries, and no reader, we are persuaded, will venture to say, that his time was not most industriously and judiciously occupied. We have read the report with the deepest interest—albeit an octavo volume of 666 pages,—and we make the unqualified acknowledgment that in our estimation Dr. B. has performed the task assigned him, thus far, with sound discrimination, and in the exercise of a judgment and good taste which will redound to his credit on both sides of the Atlantic.

It was necessary in such an expansive survey of the educational institutions of different nations, to classify the objects of his investigation; not only to consider education in its threefold relation to the physical, the intellectual, and the moral nature of man, but to regard it in its aptitudes to the different classes into which human society is, in every civilized country, inevitably arranged, by age and condition in life. The importance of such a distinction was at once perceived by the author, and instead of giving a geographical detail of the schools and systems which he examined, he first describes the institutions for the education of orphans and destitute children in England, Scotland, Germany, Prussia and Holland; then the schools for infant instruction—primary or elementary schools in France, England, and other countries—schools of agriculture and industry—seminaries for the preparation of teachers, including the normal schools of France—secondary schools; and finally, superior schools, embracing all that is most worthy of notice under each of these heads in the different countries which he visited.

The report is indeed voluminous, but we could not easily point to the chapter, or even the page, that could well have been spared, considering that the task was assigned him of making a faithful exhibition of the most important institutions of Europe. We rather indeed regret that its needful limitations precluded the author from reporting upon the Universities of Great Britain and Ireland, and the older Institutions of the Continent, appropriated to the higher grades of classical literature and science.

"They had their origin (says the author) in the wants of an early period of civilization, and have continued to be as necessary in its progress, requiring great changes, however, to enable them to keep pace with the times. Schools of arts, or polytechnic schools, have originated in the requirements of modern times, in which occupations have risen in standing and importance, or have been actually created, by the progress of science and the arts. Considered as special schools, the universities have very different objects from those which the founder of the Girard College intended as the aim of his institution, while the purposes of the polytechnic schools are strictly in accordance with those which his will points out for the highest department of his college. This being the case, a description of foreign universities would, I conceive, be out of its place in this Report. From the character of my associations, before leaving home, which naturally led to similar associations while abroad, I felt highly interested in this class of institutions, and it is with reluctance I have come to the conclusion not to give some description of them in my Report. While it is exceedingly difficult to judge of the results of university systems of different countries, especially so from the amount of talent arrayed in favour of, and even positively against, different systems, and I should make no pretensions to offer such a judgment, the institutions are by no means difficult to describe, so that a reader may conceive the form of the system, and endow that form with spirit, in proportion to the force of his own natural powers, and his experience. The differences between the university systems of Great Britain, France, and Germany, afford interesting subjects of reflection to those whose pursuits and dispositions lead them to efforts for the improvement of 'superior education.' Considering these different systems as so many experiments made under different circumstances, the study of their results, and the modifying effect of circumstances, is no less interesting than useful. The field is, however, vast; the varieties in Great Britain alone would require much space for due description, as a few words will suffice to show. The Scotch and English universities differ very much in their organization, discipline, and instruction, and even the several Scotch universities are not alike. At Glasgow, and the academical institution at Belfast, founded upon its model, the pupils enter, in general, in very early youth. The lectures are, therefore, mixed with recitations held by the professors, which, however, the large classes at Glasgow prevent from being efficacious. The students do not reside in either of these institutions. At Edinburgh, the average age of the student is greater, and the medical department assumes, relatively to that of letters, an importance which modifies the character of the school. The lesser universities of St. Andrews and Aberdeen differ more from the others in the arrangement of discipline, resulting from the residence of a part of the students in the colleges composing them, than in the character of the instruction. In the larger English universities of Cambridge and Oxford, composed of colleges and halls, in the buildings of which the students generally reside, the discipline of each college may be said to be its own, with a

general conformity to that of the university.* The same is true in regard to the instruction, with this difference, that as all the courses tend towards the preparation for university degrees and university honours, there is a general conformity in the several colleges in the subjects taught and methods of teaching. The instruction given by the tutors in the colleges is upon the same general plan, a mixture of lecture and recitation, and, as the attendance upon the lectures of the university professors is not obligatory, forms the real basis of the intellectual part of the university education. The inducements held out to exertion in these schools by the rewards which the fellowships and the stations to which they may lead hold forth, and which bring into them the greater part of the best talent of England, produce results which are of the highest order, but which cannot fairly be considered as depending mainly upon the system of instruction and discipline. It must require a very accurate knowledge of facts, with an entire absence of prejudice, to reason as to the general results of the various parts of the complex system, which has grown with the growth of these institutions themselves, and is, therefore, now very deeply rooted.

"I consider the opportunity which I enjoyed of witnessing some of the written examinations at Cambridge as of the highest value, and am no longer surprised at the attachment to this method which is there felt. It is accurate and expeditious in its results, removes all possibility of, or temptation to, show, and even the suspicion of partiality, in the distribution of important places. While I am not yet persuaded that it can supersede the viva voce method, or be employed to such an extent as to sink the use of the latter into comparative insignificance, yet, if the choice lay between the use of the one or other method extensively, I should now prefer the former.

"At the university of Dublin (Trinity College,) the advantages of the tutorial system are combined with that of the lectures by professors, which the students are enjoined to attend, and the same is the case at the recently erected university of Durham. This university has set the example of adding instruction in civil engineering to its literary courses, and has admitted the modern languages into the latter. King's College and London University College have hardly yet taken the form which time must impress upon them in their new connexion with the London University; the enactments of this recent corporation, in regard to the requirements for degrees, must ultimately regulate the higher studies of these and other institutions, presenting candidates for them. This bare enumeration will serve to show, that to give any thing like an idea of institutions so various in their character, would require much time and more space than could properly be bestowed in a report, to the purpose of which the greater part of the particulars would be found inappropriate. No doubt useful hints might be gathered, but by far the greater part of the matter would be entirely inapplicable to our purpose. For example, the system of university degrees, by which encouragement is given to general effort, and of the privilege to teach, or of stations without actual duty, by which, in many establishments, individual exertion is stimulated and rewarded, are entirely inapplicable to the circumstances of our institution. Again; the tone and modes of discipline, both in those institutions where the pupils reside and in those where they merely come at stated times to receive instruction, are inapplicable to our case, and the general organization and government are not less so. Fur-

* A very accurate account of the universities of Cambridge and Oxford is to be found in the report to the Board of Trustees of the University of Pennsylvania, by Philip H. Nicklin, Esq., one of its members.

ther, the instruction, as far as it is of a special character, qualifying for admission to the learned professions, as in the continental system, has, of course, no bearing upon our arrangements, and leaves for profitable study the subjects of at most two faculties. In these the titles of the branches themselves would be all that could serve us; for the mode of lecturing being universally adopted, the treatment of the subject depends upon the individual professor."

We hope that the author may be induced, at some future time, to furnish, either in a supplementary report, or in some other form, the result of his visits to the universities. A detail of their organizations, various and dissimilar as they are, and complicated as some of them, by long usage, have become, would be highly interesting to the scholars of this country.

However disposed some of the readers of this volume may be to complain of repetition in the statistical accounts of institutions, similar in their objects, we do not see how the reporter could have omitted any of his tabular illustrations, or individual statements, without furnishing grounds of complaint to those who will look to his volume for a specific statement of each, or any, of the prominent institutions relative to which they may wish information. It is by a minute comparison of means and results that we arrive at the most valuable truths in practical science; and certain it is that in the great science of education there is still much to be learnt, and to no people is this knowledge more important than to the inhabitants of our republic.

The state of popular education in the different parts of our extended territory is perhaps as various as in the different countries of Europe visited by Dr. Bache. However we may be disposed to congratulate ourselves on the provision made in most of the States for supporting schools, a strict examination would, we fear, demonstrate in many parts of our country, as great a destitution of all literary instruction as could be found in almost any part of Europe. In particular sections of the United States the most laudable efforts are unquestionably in operation to elevate the standard of common schools and academies to the highest point of philanthropic ambition; but whoever reads attentively the volume before us must make the acknowledgment, however painful to his *amor patriæ*, that in no part of our favoured land is the science of education fully understood, and its precepts carried into practical operation. The main reason is that little or nothing has been done to educate those who are to become the educators of the people. The means have not been provided for opening the arena of competition for the display of genius and talent in the highest of all practical arts—the discovery of the most efficient means of evolving the powers of the mind in connexion with the virtuous energies of the heart and affections. Until the business of the educator is raised to a rank correspondent in respectability with any other professional pursuit, it is not to be imagined that skill will be shown in the management of schools to a degree which the wants and faculties of the man, while "yet in the gristle," absolutely require.

This subject we know is beginning to claim attention in several of the States, and we regard it as the earnest of a spirit of higher importance to the welfare of the country, than any thing within the whole range of politics, trade, or other matters relating to mere physical improvement. It is in this point of view especially, that we could wish the Report of President Bache placed in the hands of every teacher and manager of schools throughout the country. It will show them at what an unimagined distance we are still behind, in spirit and advancement, the educational institutions of

some parts of Europe; and yet with what an accelerated motion, with the means and appliances in our possession, we may follow on in the track of a noble rivalship, and the acquirement of a distinction as flattering to the moral strength of the nation as its ships, factories, and rail roads are to its intellectual and physical energies.

As an example, appropriate to the pages of our journal, of the style and descriptive talent of the Reporter, so long an efficient *colaborateur* in the concerns of the Franklin Institute, we quote his account of the "School of Arts of Berlin."

*Institute of Arts of Berlin.**

"This institution is intended to impart the theoretical knowledge essential to improvement in the arts, and such practical knowledge as can be acquired to advantage in a school. It is supported by the government, and has also a legacy, to be expended in bursaries at the school, from Baron Von Seydlitz. The institution is under the charge of a director,† who has the entire control of the funds, of the admissions and dismissions, and the superintendence of the instruction. The professors and pupils do not reside in the establishment, so that the superintendence is confined to study-hours. There are assistant professors, who prepare the lectures, and conduct a part of the exercises, in some cases reviewing the lessons of the professors with the pupils. Besides these officers there are others, who have charge of the admirable collections of the institution, and of the work-shops, offices, &c. The number of professors is eight, and of repeaters, two. The discipline is of the most simple character, for no pupil is allowed to remain in connexion with the institution unless his conduct and progress are satisfactory. There is but one punishment recognised, namely, dismission; and even a want of punctuality is visited thus severely.

"In the spring of every year the regencies advertise that applications will be received for admission into the institute, and the testimonials of the candidates who present the best claims are forwarded to the director at Berlin, who decides finally upon the several nominations. The pupils from the provincial schools have, in general, the preference over other applicants. At the same time notice is given by the president of the Society for the Promotion of National Industry, in relation to the bursaries vacant upon the Seydlitz foundation. The qualifications essential to admission are—to read and write the German language with correctness and facility, and to be thoroughly acquainted with arithmetic in all its branches. The candidate must, besides, be at least seventeen years of age. Certain of the pupils, as will be hereafter more fully stated, require to have served an apprenticeship to a trade. The Seydlitz bursars must, in addition, show—1st. That their parents were not artizans,‡ relatives of the founder having the pre-

* Gewerbinstitut, literally, trade institute. I am indebted to the director, privy counsellor Beuth, for a lithographic outline and programme of this institution, and to the Hon. Henry Wheaton, minister of the United States at Berlin, for an account of the industrial schools of Prussia, by Captain Beaulieu, Belgian chargé d'affaires at Berlin. M. Beuth gave me every facility in visiting the institution.

† The director, M. Beuth, is also president of the Royal Technical Commission of Prussia, and has the distribution of the funds for the encouragement of industry, amounting to about seventy-five thousand dollars annually. M. Beuth is also a privy counsellor, and is president of the Society for the Encouragement of National Industry in Prussia.

‡ The object of M. Von Seydlitz appears to have been to counteract, to the extent of his power, the tendency to the increase of the learned professions, at the expense of the mechanic arts, by an inducement to a course exactly contrary to the usual one.

ference over other applicants. 2d. That they have been apprenticed to a trade, if they intend to follow one not taught in the institution. 3d. They must enter into an engagement that if they leave the mechanical career they will pay back the amount of their bursaries. There are sixty or seventy gratuitous pupils in the school, of whom eighteen are upon the Seydlitz foundation. Forty are admitted annually, this number having been adopted because it is found that, in the course of the first month, about a fourth of the newly admitted pupils fall away from the institution. Each bursar receives two hundred and twenty-five dollars per annum for maintenance. The education is gratuitous. The regular pupils enter on the first of October; but the director is authorized to admit, at his pleasure, applicants who do not desire to become bursars, but who support themselves, receiving gratuitously, however, the instruction afforded by the institution.

"The education of the pupils is either solely theoretical, or combines theory and practice, according to the calling which they intend to follow. The first division is composed of students, who receive theoretical instruction only, and who are preparing to become masons, carpenters, and joiners. They are supposed to have become acquainted with the practice of their trade before entering the institution, being required to have served, previously, a part of their apprenticeship. An excellent reason is assigned for this rule, namely, that on leaving the school such pupils are too old to begin their apprenticeship to these callings, and would, if they attempted to do so, find the first beginnings so irksome as to induce them to seek other employments, and thus their special education would be lost, and the object of the school defeated. The second division embraces both theoretical and practical instruction, and consists of three classes. First, the stone-cutters, engravers, lapidaries, glass-cutters, carvers in wood and ivory, and brass-founders. Second, dyers and manufacturers of chemical products. Third, machine-makers and mechanicians. The practical instruction is different for each of these three classes.

"The general course of studies lasts two years, and the pupils are divided into two corresponding classes. The first class is, besides, subdivided into two sections. The lower, or second, class is taught first; mechanical drawing, subdivided into decorative drawing, including designs for architectural ornaments, utensils, vases, patterns for weaving, &c., and linear drawing, applied to civil works, to handicrafts, and to machines. Second, modeling in clay, plaster, and wax. Third, practical arithmetic. Fourth, geometry. Fifth, natural philosophy. Sixth, chemistry. Seventh, technology, or a knowledge of the materials, processes, and products of the arts. The studies of the lower section of the first class are general, while those of the first section turn more particularly upon the applications of science to the arts. In the lower section, the drawing, modeling, natural philosophy, and chemistry, of the first year, are continued; and, in addition, descriptive geometry, trigonometry, stereometry, mixed mathematics, mineralogy, and the art of construction, are studied. In the upper or first section, perspective, stone-cutting, carpentry, and mechanics applied to the arts, are taught, and the making of plans and estimates for buildings, work-shops, manufactories, machines, &c. These courses are common to all pupils, whatever may be their future destination; but beside them, the machinists study, during the latter part of their stay at the institution, a continuation of the course of mechanics and mathematical analysis. The examples accompanying the instruction in regard to plans and estimates are adapted to the intended pursuits of the pupils.

"The courses of practice are begun by the pupils already enumerated as taking part in them, at different periods of their stay in the institution. The future chemists and mechanics must have completed the whole range of studies above mentioned, as common to all the pupils, while the others begin their practice after having completed the first year's course. There are work-shops for each class of pupils, where they are taught the practice of their proposed calling, under competent workmen. There are two foundries for bronze castings, one for small, the other for large castings, and the work turned out of both bears a high character. A specimen of this work is retained by the institution in a beautiful fountain, which ornaments one of the courts of the building. The models for castings are made in the establishment. In the first division of pupils, in reference to their callings, there are usually some whose art is connected with the fine arts in some of its branches, and these have an opportunity during part of the week to attend the courses of the Berlin Academy. The future chemists work for half the year in the laboratory. They are chiefly employed in chemical analysis, being furnished with the requisite materials for practice by the institution. In the shops for the instruction of mechanics are machines, for working in wood and the metals, a steam-engine of four horses' power, a forge, tools in great variety, lathes, &c. The pupils have the use of all necessary implements, according to their progress, and are gradually taught as if serving a regular apprenticeship. When capable, they are enabled to construct machines which may be useful to them subsequently, as a lathe, or machine for cutting screws, or the teeth of wheels, &c., and are furnished with all the materials for the purpose, the machine becoming their own property. In these work-shops, also, the models for the cabinet of the school are made. This is by far the most complete establishment for practice which I met with in any institution, and I believe the practice is both real and effectual. It involves, however, an expenditure which in other cases it has not been practicable to command. The scale of the whole institution is, in the particular of expenditure, most generous.

"This is one specimen of the various plans which have been devised to give practical knowledge of an art in connexion with theory in a school. It is first most judiciously laid down that certain trades cannot be taught to advantage in a similar connexion, but that the practical knowledge must be acquired by an apprenticeship antecedent to the theoretical studies. There are besides, however, a large number of trades, the practice of which is to be taught in the institution, and requiring a very considerable expenditure to carry out the design properly. This could not be attempted in a school less munificently endowed, and requires very strict regulations to carry it through even here. The habits of a school work-shop are, in general, not those of a real manufactory, where the same articles are made to be sold as a source of profit; hence, though the practical knowledge may be acquired, the habits of work are not, and the mechanic may be well taught but not well trained. At the private school of Charonne, work-shops were established, giving a variety of occupation to the pupils; but the disposition to play rather than to work, rendered these establishments too costly to be supported by a private institution, and the plan adopted instead of this, was to make the pupils enter a regular work-shop for a stated number of hours, to work for the proprietor or lessee. This plan remedies one evil, but introduces another, that as the machinist takes orders, with a view to profit, the work may have so little variety as only to benefit a small class of the pupils. The pupils at Charonne are, however, under different circum-

stances from those at Berlin; they are generally younger, and, being independent of the school, where they pay for their education, are not under the same restraint as in the other institution; hence the experience of the one school does not apply in full force to the other. At Dresden, in a school somewhat similar to that of Berlin, a different mode from either of those just mentioned has been adopted. An arrangement is made with a number of mechanics, of different occupations, to receive pupils from the schools as apprentices, allowing them the privilege of attending, during certain specified hours of the day, upon the theoretical exercises of the institution. Where such an arrangement can be made, the results are unexceptionable, and the advantages likely to accrue to the mechanic arts, from the union of theory with practice, will offer a strong inducement to liberally disposed mechanics to take apprentices upon these terms. Small workshops, connected with an institution, must necessarily offer inferior advantages, even if closely regulated, so as to procure the greatest possible amount of work from the pupils; this should not be done for the sake of the profit, but to give him genuinely good habits.

"The difficulties in giving practical instruction in the chemical arts are not to be compared with those under discussion, and will be found to have been satisfactorily obviated in several schools. This subject will receive its more appropriate discussion in connexion with the polytechnic institution of Vienna, where the chemical department, at least as far as manufacturing chemistry is concerned, is generally recognised as having produced the best results of any yet established.

"Returning to the subject of the theoretical instruction in the Berlin institute of arts, the following statement will serve to show the succession of the courses, with the time devoted to each:—

Winter Course.

"Monday.—*First Class.* First division—drawing and sketching machines, eight A. M. to twelve o'clock. Discussion of machines, estimates of power, &c, two P. M. to five P. M. Second division—machine drawing, eight to ten. Modeling in clay, ten to twelve. Physics, two to five. *Second Class.* Machine-drawing, eight to ten. Modeling, ten to twelve. Elements of geometry, two to four. Repetition of the lecture, four to five.

Tuesday.—*First Class.* First division—architectural plans and estimates, eight to twelve. Practical instruction in machinery, two to five. Second division—ornamental and architectural drawing, eight to twelve. Trigonometry, two to five. *Second Class.* Ornamental and architectural drawing, eight to twelve. Physics, two to four. Repetition of the lecture, four to five.

Wednesday.—*First Class.* First division—original designs, eight to twelve. Discussion of machinery. Second division—mineralogy, eight to nine. Machine-drawing, nine to twelve. Trigonometry, two to five. *Second Class.* Machine-drawing, eight to twelve. Practical arithmetic, two to five.

Thursday.—*First Class.* First division—Drawing and sketching machines, eight to twelve. Architectural instruction, estimates, two to five. Second division—decorative and architectural drawing, eight to ten. Modeling in clay, ten to twelve. Trigonometry, two to five. *Second Class.* Decorative and architectural drawing, eight to ten. Modeling in clay, ten to twelve. Physics, two to four. Repetition of the lecture, four to five.

Friday.—*First Class.* First division—architectural plans, eight to twelve.

Practical instruction in machinery, two to five. Second division—machine-drawing, eight to twelve. Physics, two to five. *Second Class.* Machine-drawing, eight to twelve. Elementary mathematics, two to four. Repetition of the lesson, four to five.

SATURDAY.—*First Class.* First division—perspective and stone-cutting, eight to twelve. Original designs, two to five. Second division—mineralogy, eight to nine. Decorative and architectural drawing, nine to twelve Trigonometry, two to five. *Second Class.* Decorative and architectural drawing, eight to twelve. Practical arithmetic, two to five.

The summer term, which follows this, embraces the practical instruction.

Summer Term.

MONDAY—*First Class.* First division—in the work-shops from seven A. M. to twelve, and from one until seven P. M. Second division—machine-drawing, eight to twelve. Applied mathematics, two to five. *Second Class.* Machine-drawing, eight to ten. Modeling, ten to twelve. Chemistry, two to four. Repetition, four to five.

TUESDAY.—*First Class.* First division—analytical dynamics, eight to nine. Drawing of machines from original designs, nine to twelve. Machinery, two to five. Second division—decorative and architectural drawing, eight to twelve. Chemistry, two to five. *Second Class.* Decorative and architectural drawing, eight to twelve. Elementary mathematics, two to four. Repetition, four to five.

WEDNESDAY.—*First Class.* First division—in the work-shops from seven to twelve, and from one to seven. Second division—machine-drawing, eight to ten. Modeling, ten to twelve. Applied mathematics, two to five. *Second Class.* Machine-drawing, eight to twelve. Practical arithmetic, two to four. Materials used in the arts, four to five.

THURSDAY.—*First Class.* First division—in the work-shops from seven to twelve, and from one to seven. Second division—machine-drawing, eight to ten. Modeling, ten to twelve. Applied mathematics, two to five. *Second Class.* Decorative and architectural drawing, eight to ten. Modeling, ten to twelve. Chemistry, two to four. Repetition of the lesson, four to five.

FRIDAY.—*First Class.* First division—analytical dynamics, eight to nine. Drawing of a machine for an original design, nine to twelve. Machinery, two to five. Second division—chemistry, eight to nine. Applied mathematics, nine to twelve. Chemistry, two to five. *Second Class.* Machine-drawing, eight to twelve. Elementary mathematics, two to four. Repetition of the lesson, four to five.

SATURDAY.—*First Class.* First division—in the work-shops from seven to twelve, and from one to seven. Second division—decorative and architectural drawing, eight to twelve. Applied mathematics, two to five. *Second Class.* Decorative and architectural drawing, eight to twelve. Practical arithmetic, two to four. Materials used in the arts, four to five.

The chemical division of the practical classes is engaged every day in the laboratory. On Tuesday and Wednesday the library is open for reading from five to eight, P. M.

"The collections for carrying out the various branches of instruction are upon the same liberal scale with the other parts of the institution. There is a library of works on architecture, mechanics, technology, the various arts, archeology, &c., in German, French and English. This library is open

twice a week, from five to eight in the evening, to the pupils of the first class of the school, and to such mechanics as apply for the use of it.

"There is a rich collection of drawings of new and useful machines, and of illustrations of the different courses, belonging to the institution. Among them is a splendid work, published under the direction of Mr. Beuth, entitled Models for Manufacturers and Artisans (Vorlegeblatter fur Fabricanten und Handwerker), containing engravings by the best artists of Germany, and some even from France and England, applicable to the different arts and to architecture and engineering. Among the drawings are many from original designs by Shenckel, of Berlin.* There is a second useful but more ordinary series of engravings, on similar subjects, also executed for the use of the school. These works are distributed to the provincial trade schools, and presented to such of the mechanics of Prussia as have especially distinguished themselves in their vocations. The collection of models of machinery belonging to the school probably ranks next in extent and value to that at the Conservatory of Arts of Paris. It contains models of such machines as are not readily comprehended by drawings. Most of them are working models, and many were made in the work-shops of the school. They are constructed, as far as possible, to a uniform scale, and the parts of the models are of the same materials as in the actual machine. There is an extensive collection of casts, consisting of copies of statues, basso-relievos, utensils, bronzes, and vases of the museums of Naples, Rome, and Florence, and of the British Museum, and of the models of architectural monuments of Greece, Rome, Pompeii, &c., and copies of models, cameos, and similar objects; those specimens only have been selected which are not in the collection of the Academy of Fine Arts of Berlin, to which the pupils of the Institute of Arts have access. There are good collections of physical and chemical apparatus, of minerals, of geological and technological specimens.

"The instruction is afforded in part by the lectures of the professors, aided by text-books specially intended for the school, and in part by the interrogations of the professors and of the assistants and repeaters. At the close of the first year there is an examination to determine which of the pupils shall be permitted to go forward, and at the close of the second year to determine which shall receive the certificate of the institute. Although the pupils who come from the provinces are admitted to the first class of the institute, upon their presenting a testimonial that they have gone through the courses of the provincial schools satisfactorily, it frequently happens that they are obliged to retire to the second, especially from defective knowledge of chemistry.

"The cost of this school to the government is about twelve thousand dollars annually, exclusive of the amount expended upon the practical courses and upon the collections—a very trifling sum, if the good which it is calculated to do throughout the country is considered. The comparatively recent existence of the institution does not admit of appealing to decided results which have flowed to the mechanic arts in Prussia from its establishment, but there can be no doubt of its tendency, and its pupils are already known to be making their way successfully, in consequence of the advantages which they have here enjoyed."

We trust, it will not be very long before the institution of seminaries, analogous in principle to the one above described, will become an object of

* A copy of this work has been most liberally presented to the Girard College by the Technical Commission, of which, Mr. Beuth is president. The work having been published by the government, is not sold.

legislative regard in some, at least, of the United States. Schools for the blind, and for deaf mutes, have taken root effectually in the philanthropy of the country, and it is scarcely to be questioned that the tendency of our civism is to the adoption of every useful discovery, whether in mechanical or moral science, as soon as its character of utility and beneficence has received the sanction of an evident demonstration.

G.

Scientific Memoirs, selected from the transactions of Foreign Academies of Science, and learned Societies, and from Foreign Journals. Edited by Richard Taylor, F. S. A.

The enterprise of the Editor of this valuable series of papers we can readily conceive to have been dictated by the pure love of Science, and the pleasure derived from witnessing its extensive and increasing propagation in every country where the English language is read and spoken. Without some such undertaking, many of the most learned and original papers, published in Russia, Prussia, Germany, France, and Italy, would remain excluded from English readers, excepting the few who could gain access to the foreign Journals, and were able to relish their perusal in a foreign tongues

The Editor, after being encouraged to commence the translation and publication of the best of the foreign memoirs, a work which necessarily involves no little expense, was obliged, on the completion of the first volume to suspend it for some time for want of adequate patronage. We are pleased to find that this result has excited a feeling of regret among the friends of Science in Great Britain, and that the Editor is again encouraged to persevere. Part 2d, of the 2d vol., (part 6th, of the whole) has just been received by the Franklin Institute, and we can do no less than speak in terms of high commendation of the beauty of the paper, and of the execution, typographical and lithographical.

The contents of part VI, are,

1. Memoir on the Polarization of Heat. By Macedoine Melloni.

2. General Theory of Terrestrial Magnetism. By Carl Friedrich Gauss, Professor in the University of Gottingen.

3. On a new Instrument for the direct Observation of the changes in the intensity of the horizontal portion of the terrestrial magnetic force. By Carl Friedrich Gauss.

4. Observations on the arrangement and use of the Bifilar Magnetometer. By Wilhelm Weber.

5. Contributions to our knowledge of Phytogenesis. By Dr. M. J. Schleiden.

The names of the authors of these memoirs are sufficient to impress the stamp of high value on the contents of part VI., and although the essays may be too learned for popular perusal, they ought to be accessible to teachers and professors of Science, and hence, are deserving a place in every College Library, and collection of learned works on Science. In the subscription list we find but five copies for the United States, and those all in Philadelphia except one, viz: Columbia College, New York.

G.

Physical Science.

Nashville University, Jan. 1, 1840.

To the Committee of the Franklin Institute on Meteorology.

Gentlemen,—Believing that your committee on Meteorology would gladly receive a few observations during the late solstice, I send you my notes of the weather at that time. I begin with Dec. 21st, and continue them with some intermissions to the 24th. If you think them worthy, you may send them in such form as you think fit, to the South African L. & Phil. Institution. The remainder of my communication is intended for your Committee.

The past summer exceeded in drought, not only that of 1838, but any one ever remembered by the oldest inhabitants. There had been less rain than usual, the winter preceding, and although there were some good showers about the beginning of May, the ground was remarkably dry. In June, July, and August, but especially in the last two, we *suffered* for want of rain, and springs failed, that never failed before. The beautiful Aurora of Sept. 3, was followed by a copious rain in about 20 hours. Clear weather succeeded on the 9th, and there was no more rain until Nov. 1st, with the exception of light falls on the 17th, and 27th of Sept., and 27th Oct. With the 1st of November, the springs and creeks began to swell a little, and the popular opinion was that the rise was caused by the increase of cold. There was no rain in this vicinity sufficient to produce the effect, but there were rains at the time west of the mountains and north of us.

During November we had 3.64 inches of rain, and on the 25th day the Ther. fell to 9°, while the Bar. rose to 30.08 inches.

Such a temperature in November is very unusual—from May until this day the Ther. has not been so low, nor the Bar. as high. In December rain began at 8 P. M. on the 6th, and continued moderately until the 12th, changing into snow on the 9th at night, half an inch deep, (the first of the season) making of rain in all only .83in.

December, 12 and 13, cloudy—wind SW., SE., and East; 14th cloudy—SW.; 15th, clear—W.; 16th, cloudy—N. E.; 17th, clear—W.; Ther. 17 min. I state the above facts, because the newspapers inform us of a violent storm in the East on the 14th and 15th.

December 30th, a snow storm began here at day-break with an East and NE. wind, and continued until 4½ P. M., when it lay 7 inches deep. It was followed by hail all night.

December 31, a pretty thick crust on the snow; hail continued till 9 A. M., and then a light snow through the day, Bar. 29.36, at noon began to rise at 2 P. M., when it was 29.38, wind N.; cloudy all night, but clear this morning. The amount of rain in December 2.70 inches.

Mean temperature, June, 73.17; July, 77.88; August, 77.82; September, 65.58; October, 64.65; November, 41.11; December, 34.17; max. temp. of summer 95°--river too low for boats.

Very respectfully, Yours, &c.,

James Hamilton.

Meteorological Observations, at the Winter Solstice of 1839, *made in conformity with the instructions of the South African Literary and Philosophical Institution, at the University of Nashville, Tennessee, in North Latitude,* 36° 09′ 33″, *W. Long.* 86° 49′ 03; *"by* JAMES HAMILTON, *Prof. Math. and N. Phil.*

December 21, 1839.

	External Ther.	Attach'd Ther.	Barom.				
6 A.M.	35	39	29.22	c	S.E.	0	Thin clouds.
7	35.5	42	29.22	c	S.E.	0	Clouds heavier; sprinkles, 7h. 25m.
8	36.5	42	29.21	R	S.E.	0	Gentle rain.
9	37.5	42	29.21	R	S.E.	0	Rain heavier.
10	39.5	42	29 21	R	S.E.	0	Rain lighter; W. nearly cl'r. 10h. 40m.
11	40.5	42	29.19	c	S.W.S.E.	0	Clouds thinner; mist 11h. 30m.
12	44	42	29.14	c	S.E.	0	
1 P.M.	43.5	42	29.11	c	S.	0	Clouds heavy.
2	43	43	29.10	c	S.	0	Clouds lighter.
3	43.5	43	29.08	c	S.E.	0	Double currents S.SE. at 3h 30m.
4	43.3	44	29.07	c	S.	0	
5	41.5	44	29.07	R	S.	0	Clouds breaking.
6	41	44	29.05	c	S.	0	Clouds thinner; sprinkle, 6h 30m.
7	40	44	29.05	c	S.	0	Do. heavy some places, light others.
8	41.5	44	29.04	c	SW.	1	Do. breaking in South.
9	41	44	29.01	R	SW.	1	Light rain.
10	40.5	44	28.99	R	SW.	1	Heavier rain.
11	40	44	28.98	c	SW.	1	
12	40.5	45	28.98	R	SW.	1	

December 22.

1 A.M.	40	45	28 98	c	W.	2	
2	39.5	46	29.01	c	W.	1	
3	40.5	46	29.01	c	W.	1	
4	38	44	29.04	c	W.	2	
5	38.5	43	29.05	c	W.	1	
6	38	43	29.06	c	W.	1	From 6h. 10m. to 6h. 25m. wind 2.
7	36.5	42	29.06	R	W.	1	
9	35	41	29.11	c	W.	1	At 12h. 40m. a few flakes of snow.
1 P. M.	35	42	29.14	c	W.	3	
3	34	42	29 20	c	W.	1	

December 23.

8 A.M.	36	38	29.50	c	NW.	1	
9	31.5	35	29.53	c	NW.	1	
10	32	35	29.53	c	NW.	1	
11	32.5	35	29.53	c	NW.	1	
12	33	35	29.52	c	NW.	1	
1 P.M.	33	35	29.50	c	NW.	1	
2	34.5	35	29.50	c	NW.	1	
3	Do.	Do.	Do.		Do.		

December 24.

9 A.M.	35	35	29.65	c	W.	1	
12	36	35	29.62	c	W.	1	
3 P.M.	37	36	29.60	c	W.	1	

December 25, min. 17.

Meantime found by means of transit, and kept by a superior clock, not varying 30 seconds in 6 weeks. Ther. Fahrenheit. Barometer of English manufacture; diameter of the tube $\frac{4}{10}$ inch, cup. 2 inches; in good order; Dolland, London; height above ground 38 feet, and 128 feet above low water of the Cumberland river—external thermometer 35 feet above ground, facing North.

Mechanics' Register.

LIST OF AMERICAN PATENTS WHICH ISSUED IN JANUARY, 1839, *With Remarks and Exemplifications by the Editor.*

1. For an apparatus for *Evaporating Fluids;* William Henry, Laporte, Laporte county, Indiana, January 8.

The patentee tells us that "the nature of his improvement consists in so rarifying the air in the boiling apartment, by means of fires lighted therein, at the back, creating a strong draft through a flue, or flues, above the fire, which conduct off the steam rapidly from the surface of the liquid in the boiler, causes the evaporation to go on more expeditiously than heretofore, removes the nuisance and inconvenience arising from the steam in the manufactory, saves fuel, lessens the number of boilers required, and improves the quality of the sugar, salt, or other article manufactured." We have here a promising list of valuable results from the discovery patented. The matter is not very clearly explained, but the thing appears to consist in the making of an additional fire above, and behind, the tops of the boilers, so as to produce a more rapid draught up the chimney. The patentee says that the rapidity of the evaporation will be so far increased, that one pound of fuel burnt for rarifying the air will be as valuable as four under the boilers. We do not believe this, as according to our understanding of the matter, the rapidity of evaporation from a boiler is proportioned to the fire surface of the boiler, and the intensity of the fire; as to draught, it should be sufficient to carry off the vapour, and the fire under the boilers may certainly answer this purpose. The claim is to "the before described method of evaporating liquids, by rarifying the air in the boiling room.

2. For an improvement in *Bedsteads;* Thomas Early, county of Williamson, Tennessee, January 8.

The subject of this patent seems to us to be one of the most trifling on record, although it wears the garb of novelty. At the distance of two or more inches from the posts of a low post bedstead, four high posts are to be placed, for the purpose of sustaining curtains. These high posts are to be attached to the low ones by iron straps at their lower ends; that is all. The advantage derived is the "allowing the bed covering to hang over the bedstead on all sides, without the interference of curtain posts, uniting *taste* with convenience." The claim is to "the adding to, or combining with, the common bedstead, curtain posts, as above described." Animadversion is not necessary.

3. For a *Submarine Excavator;* William P. Brayton, and James Hamilton, city of New York, January 8.

This apparatus is intended for removing the dirt, or mud, from docks

and slips, and for clearing channels. It consists mainly of a platform, suitably framed, and having on its lower side scrapers, or buckets, which extend from side to side, hinged by one edge to the platform, the other edge being capable of being opened and closed. This platform may be suspended between scows, and let down and raised by means of windlasses, when on drawing it forward on the bottom of the dock, slip, or channel, the buckets, or scrapers, which stand in a range like the slats of a window blind, are to collect the dirt.

The claim is to "the application of said scrapers, or buckets, for the purpose aforesaid, and in combination with the platform, chains, and coulters, or pins, and with the other parts of the machine, as described."

We apprehend that this machine will be liable to serious objections. If made to operate in soft mud, nearly the whole, we think, will be washed out in raising the platform; in operating upon a bottom moderately hard, the resistance to the motion of the machine forward, will be greater than can be readily overcome.

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4. For a machine for *Sharpening Curriers' Knives*; Warren Egleston, city of Troy, New York, January 8.

A bench is to be prepared on which the knife may be secured, so that the edge, or side, to be rubbed may be placed, and held in the proper position for the action of the rub stone. This latter is attached to a suitable frame, which is guided by a rod, or wire, extending along on one side of the frame, the parts being so constructed as to allow a free motion to be given by hand to the rub stone, both lengthwise, and crosswise.

The claim is to "the combination of the bench with the rub stone, the whole being constructed and arranged in the manner substantially as described."

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5. For packing and gearing *Mill Spindles;* David D. Wagner, city of Pittsburgh, Pennsylvania, January 8.

Claim. "The employment of the metal box attached to the bridge tree by keys, and moving longitudinally and transversely upon it, in combination with the mode of adjusting by means of screws, the carriage which holds the stepping of the lower pole of the spindle. Secondly, the employment of a metal bush containing packing through which the spindle is permitted to revolve, which packing may be tightened or slackened, even whilst the machine is in motion, by a follower acted upon by screws movable from without, as described."

There are several patents for devices the same in object with the foregoing, but the arrangement in that above metioned has been deemed sufficiently new, to obtain the grant of a patent; we do not see any thing in it, however, demanding special notice.

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6. For an improvement in the manufacture of *Cigars;* William D. Groff, Marietta, Lancaster county, Pennsylvania, January 8.

These cigars, are to be made like other cigars, but instead of the genuine Havana, the leaf of the sun-flower, or of Rhubarb, or of both combined, is to be used. The patentee, for the sake of those to whom long habit has rendered the taste of tobacco desirable, sometimes adds a wrapper of this material, but he claims, and will probably be allowed to smoke, "the prepared

leaves of the sun-flower, and rhubarb plant, separately or combined, for the formation of cigars, and to be used as a substitute for tobacco."

7. For a *Life and Anchor Boat;* Joseph Francis, city of New York, January 11.

The claim made is to "the adaptation and arrangement of air-tight tubes, with holes in the bottom of the boat, in combination, and in the manner and for the purpose set forth." The boat is to be rendered buoyant by means of closed metallic tubes, usually placed lengthwise of the boat, and in all cases occupying the bottom portion only. A flooring is to be laid above these tubes, and openings made through this flooring, and through the bottom of the boat, which openings are to be closed by plugs, on the withdrawal of which, any water that may have been shipped will run out, without baling, the buoyancy being such as to raise the floor above the surface of the water. The name of *Anchor boat*, is given, as it is intended to use this boat for carrying out an anchor from a ship, by suspending said anchor under the boat, by means of two hawsers, passing through the openings in its bottom; one hawser being attached to the stock, and the other to the fluke of the anchor.

8. For a *Glass Socket Lamp;* Henry Whitney, and Thomas Leighton, Cambridge, Middlesex county, Massachusetts, January 11.

"The nature of our invention consists in uniting the peg to the fount of a socket lamp, in such way as that the glass blower finishes both peg and fount, and completes the article by one simple operation of blowing it in a mould." The manipulation for effecting this object is fully described, and a claim made to "the peculiar mode described of making a socket lamp in such a way as to unite the fount and peg of the lamp, made of separate portions of glass, by one simple operation of blowing it in a mould."

9. For an *Excavating Machine;* G. W. Cherry, Washington, District of Columbia, January 16.

The main intention of this machine is for ditching and embanking, and it "consists chiefly in a wheel with cutters on the periphery to shape the bottom of the ditch, and cutters on the sides to shape the sides of the ditch." The different modes of forming this machine are represented in twenty-eight different figures, and the claims amount to twelve; these we do not copy, as they would not be explanatory, nor do we think it necessary to discuss the merits of the plan, or rather plans, as the project still remains an untried one, and we apprehend that it stands but little chance of going into actual operation.

10. For *Propelling Canal Boats;* Thomas Jackson, Reading, Berks county, Pennsylvania, January 18.

"My improvement consists in placing two wheels beside each other, under the stern of the boat, which wheels are to revolve in contrary directions perpendicular to a line of the boat from stem to stern; and in the application of dead woods, with their appurtenances, for protecting the wheels from the sides of the canal, tow lines, &c."

The wheels have vanes, like those of a windmill, inserted at an angle of about 60 degrees with the axle; the claim is to "the mode of applying wheels constructed and arranged as above described, to the stern of the

boat. Likewise the openings and slides in the deadwoods on each side, to admit water to pass through when the boat is heavily laden."

So far as such wheels are concerned, there is little or no novelty in the plan. The last claim refers to openings in the sides of the deadwood, which are closed by shutters when the boat is light, but which are opened to admit water to the wheels when the bottom of the boat is near to the bottom of the canal.

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11. For *Life Boats;* George Young, city of Philadelphia, Pennsylvania, January 21.

Copper tubes are to be employed to obtain buoyancy, as in the boat described under No. 7; but the patentee says, "Copper tubes having been previously employed for giving buoyancy to boats and other vessels, I do not claim the application of them for that purpose, but what I do claim in the construction of a life boat, as described, is the placing of tubes, or tanks, so as to extend from gunwale to gunwale, to the keelson, as herein set forth, in combination with the screw stoppers, either with or without valves, for the purpose, and in the manner made known. I claim, likewise, the openings in the bottom of the boat, in combination with sliding valves or shutters, and a rod, or handle for operating the same, constructed and located as described."

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12. For a *Churn;* Milo B. Hough, Dover, Cayahoga county, Ohio, January 21.

This is to be a vertical churn, within which are to be three vertical shafts, which are to be made to revolve by means of wheels and pinions. Each of the shafts is furnished with beaters, and at their upper ends, above the surface of the cream, is to be placed flat pieces, which are to operate as fans. The claim is to "the combination of the fans on the upper ends of the shafts, with the beaters, in the manner, and for the purpose described." In what way the fans are to promote the formation of the butter, we are not informed. As respects the application of several revolving shafts in this churn, there is no novelty in it, nor is there any thing in the whole affair which we can find cause to commend.

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13. For *Clips for the shafts of Carriages;* John Cooper, city of New York, January 22.

The claim under this patent is to "the so constructing the box joints, in shaft clips for carriages, as that the pipe eye, or connecting end of the shaft strap, shall not depend upon the bolt for its support, but, on the contrary, upon the box or case in which it is enclosed, in the manner described." The peculiarity of construction in this clip, cannot be shown without the drawings.

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14. For an improvement in *Saw Mills;* Eden Baldwin, Ashfield, Franklin county, Massachusetts, January 31.

The said improvement consists in an apparatus employed for setting the log to the saw, the description of which is made to occupy eight full pages of record. The claims alone would not afford any correct notion of the arrangement, and there is too much complexity in the affair to allow of verbal description, and, we think also, too much to admit of the extensive adoption of the plan.

On the Strength and other Properties of Cast Iron obtained from the Hot and Cold Blast. By William Fairbairn, Esq.

[concluded from vol. xxiv, page 397.]

There cannot be a doubt that the phenomenon of cohesive force is strongly developed in the preceding tables; the minute crystalline particles of the bars are acted upon by loads, which, in the heavier weights, are almost sufficient to produce fracture: yet fracture is not (except in one instance) produced, and to what extent the power of resistance may yet be carried is left for time to determine. It nevertheless appears from the present state of the bars (which indicate a slow but progressive increase in the deflections) that we must at some period arrive at a point beyond their bearing powers; or otherwise to that position which indicates a correct adjustment of the particles in equilibrium with the load. Which of the two points we have in this instance attained is difficult to determine: sufficient data are however adduced to show that the weights are considerably beyond the elastic limit,* and that cast iron will support loads to a much greater extent than what has usually been considered safe, or beyond that point where a permanent set takes place. But in whatever way this may be determined, it is obvious the preceding experiments give greater indications of strength than has generally been supposed cast iron would do; and should the bars continue to support the loads for a few years longer, there cannot exist a doubt as to the security of this metal under applications hitherto unknown; and the same may be said of other materials.

In the 14th Table we shall find inch square bars loaded on the middle, within a few pounds of weights sufficient to break them; we shall also find the bars considerably bent, and the resisting powers in full operation to sustain the load. Now the question to be determined by this experiment is, the nature of this resistance; and to show in the first instance whether the resisting power of the extended particles below, and the powers of the condensed ones operating above, are sufficient at all times *ad infinitum* to support the load; or whether those particles, instead of being united (as we suppose) with a permanent force, nicely balanced at all points of resistance, are not absolutely giving way; and by slow, though imperceptible degrees, becoming hourly weaker, until the cohesive power is entirely destroyed and rupture takes place.

It is not my intention in this place to offer any opinion upon the cohesive properties of matter, but simply to inquire how far the bearing powers of cast iron can be depended upon.

It is evident from these experiments that both sorts of hot and cold blast iron possess that power in a high degree; and we need only refer to the experiments for examples to show the patient tenacity with which so heavy a load is supported. At first sight it would appear, that the heavier loaded bars were progressively giving way, as the deflections continue to increase since the loads were permanently fixed; this defect is however not more conspicuous in the bars supporting 448 lbs., than in those supporting 392 lbs.;

* The elastic limit is that point where bodies under strain lose the power to restore themselves when the load is removed; a property which is strongly exemplified in cast iron. It has been considered by many that materials cannot be loaded with safety beyond that point.

the deflection is even greater in the latter, arising in all probability from a greater degree of ductility in the bars.

I hope shortly to induce my friend Mr. Hodgkinson, Professor Barlow, or some other able mathematician, to investigate this subject, and by close analysis to demonstrate those truths, so essential to the interests of all engaged in the use of the metals, but more particularly in reference to the security of the public at large.

Effects of Temperature.

When the multiplicity of objects to which cast iron is applied, and the innumerable situations in which it is placed, is considered, I may venture to state, that in every work of which cast iron forms the whole or a part of the structure, it is more or less liable to change. The rapidity with which it imbibes, and the facility with which it parts with caloric, is in itself a sufficient consideration for the labour I have bestowed upon these inquiries.

The present investigation would have been less satisfactory had the experiments on the effects of temperature been omitted; and I trust, the annexed Tables, which exhibit hot and cold blast iron under various gradations of heat, will not be without their uses in the future application of this material.

Rondelet, in his "*Traite de Bâtir*," has given and collected results from experiments, made by himself and others, on the expansion of bodies under the effects of heat; but I am not aware of any that have been made to ascertain the transverse strength of metallic substances under the various changes of temperature. It is well known that the effects of heat upon iron have not escaped the notice of philosophers; but I believe no writers on this subject have conducted their experiments in any way analogous to those now under consideration.

The celerity with which heat passes through the metals, and the frequent recurrence of iron being the medium of communication between fluids and this powerful agent, it is not surprising that the changes of temperature thus induced should cause such visible indications of deterioration in the material. Gas retorts, and all those vessels exposed to the alternate changes of the heating and cooling process, are considerably injured by the expansion and contraction of the parts; and no doubt the destruction of the metals is much accelerated when they are worked up to a high and excessive temperature. Probably steam-boilers are not so much injured as those above-mentioned, as the temperature is kept moderately low by the water they contain, which seldom exceeds 212°. The same causes are, nevertheless, in operation, and must continue to be so under the varied influences of calorific action.

Had time permitted, it was my intention to have pursued the experiments on temperature under a much greater degree of form and change than is here exhibited. For example, it might have been desirable not only to load the bars until they were broken, but also to charge them with different weights, and, by alternate heating and cooling, to have ascertained how far the bars so charged were affected by the change. Such an extension of the experiments might have led to the development of some new feature in the actions thus produced, and that more particularly by the introduction, abstraction, re-introduction, &c. of the different increments of heat. As it is, the bars were all broken at the temperatures indicated in the tables.

TABLE XV.—Coed-Talon, Cold Blast.

To determine the relative strengths of Coed-Talon Hot and Cold Blast Iron, to resist a transverse strain under different degrees of temperature.

No. 2 Iron, Experiment 1. Depth of bar, 1.008 Breadth of do. 1.024 Distance between supports, 2 ft. 3 in.	Weight in lbs.	Deflection in inches.	Permanent Set.	Temp. Fahr.
	112	.034	..	26°
	224	.071	.007	
	336	.101	.010	
	448	.142		
	560	.189	.017	
	672	.224	.051	
	784	.271	.030	
	896	.341		
	994	broke		
∴ Ultimate deflection = .385. This bar was broken in the open air during intense frost.				

No. 2 Iron, Experiment 2. Depth of bar, 1.020 Breadth of do. 1.005 Distance between supports, 2 ft. 3 in.	Weight in lbs.	Deflection in inches.	Permanent Set.	Temp. Fahr.
	112	.041	+	28°
	224	.090	.009	
	336	.132	.011	
	448	.187		
	560	.242	.027	
	672	.310		
	784	.382	.053	
	896	.461	.082	
	938	broke		
∴ Ultimate deflection = .487. This bar was broken in the open air.				

No. 2 Iron, Experiment 3. Depth of bar, 1.006 Breadth of do. .996 Distance between supports, 2 ft. 3 in.	Weight in lbs.	Deflection in inches.	Permanent Set.	Temp. Fahr.
	112	.040	+	32°
	224	.076	.007	
	336	.117	.010	
	448	.156	.013	
	560	.197	.018	
	672	.244	.024	
	784	.296	.035	
	896	.352	.049	
	952	(.380)	broke	
This bar was broken when buried in snow.				

No. 2 Iron. Experiment 4. Depth of bar, 1.006 Breadth of do. 1.021 Distance between supports, 2 ft. 3 in.	Weight in lbs.	Deflection in inches.	Permanent set.	Temp. Fahr.
	112	.035	..	32°
	224	.074	..	
	336	.114	+	
	448	.151	.007	
	560	.204	.012	
	672	.252	.021	
	784	.311	.033	
	896	.374	.051	
	980	(.420)	broke	
This bar was broken when buried in snow.				

No. 2 Iron. Experiment 5. Depth of bar, 1.008 Breadth of do. 1.023 Distance between supports, 2 ft. 3 in.	Weight in lbs.	Deflection in inches.	Permanent set.	Temp. Fahr.
	112	.034	..	114°
	224	.072	+	
	336	.104	.005	
	420	.144	.008	113°
	560	.182	.013	
	672	.224	.019	
	784	.274	.028	112°
	896	(.324)	broke	
Broken in water.				

Results reduced to those of bars 1.00 *in. square, and* 2 *ft.* 3 *in. between supports.*

	Temp.	Specific gravity.	Modulus of elasticity.	Breaking Weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1st, No. 2 Iron	26°	6.955	12994400	851	.411	349.8
Experiment 2nd, No. 2 Iron	28°	..	12603700	897	.4967	445.6
Mean,		6.955	12799050	874	.4538	397.7
Experiment 3rd, No. 2 Iron	32°	6.955	13506700	940.7	.383	360.3
Experiment 4th No 2 Iron	32°	..	15148200	958.5	.422	404.5
Mean,		6.955	14327450	949.6	.402	382.4
Experiment 5th, No. 2 Iron	113°	6.955	14168000	812.9	.336	273.1

The microscopic appearance of this iron will be found at No. I. Table, on the transverse strain.

TABLE XVI. Coed-Talon, Hot Blast.

No 2 Iron. Experiment 1. Depth of bar 1.056 Breadth of do. 1.004 Distance between supports, 2 ft. 3 in.	Weight in lbs.	Deflection in inches.	Permanent Set.	Temp. Fahr.
	112	.030	..	16°
	224	.069	+	
	336	.108	.008	
	448	.150		
	560	.199	.018	
	672	.251		
	784	.314	.039	
	896	broke		

∴ Ultimate deflection =.366. This bar was broken during intense frost.

No. 2 Iron. Experiment 2. Depth of bar, 1.030 Breadth of do. 1.010 Distance between supports, 2 ft. 3 in.	Weight in lbs.	Deflection in inches.	Permanent Set.	Temp. Fahr.
	112	.035	..	16°
	224	.075	+	
	336	.120	.008	
	448	.166		
	560	.220	.020	
	672	.292		
	784	.351	.045	
	882	broke		

∴ Ultimate deflection =.402. Broken in the open air.

No. 2 Iron. Experiment 3. Depth of bar, 1.033 Breadth of do. 1.012 Distance between supports, 2 ft. 3 in.	Weight in lbs.	Deflection in inches.	Permanent Set.	Temp. Fahr.
	112	.036	+	32°
	224	.075	.006	
	336	.114	.010	
	448	.155	.016	
	560	.203	.022	
	672	.246	.031	
	784	.304	.041	
	896	.363	.054	
	1008	(.422)	broke	

This bar was broken when buried in snow.

No. 2 Iron. Experiment 4. Depth of bar, 1.020 Breadth of do. 1.010 Distance between supports, 2 ft. 3 in.	Weight in lbs.	Deflection in inches.	Permanent Set.	Temp. Fahr.
	112	.036	..	32°
	224	.074	+	
	336	.114	.005	
	448	.154	.009	
	560	.202	.014	
	672	.252	.024	
	784	.312	.039	
	896	.381	.060	
	952	(.415)	broke	

This bar was broken when buried in snow.

No. 2 Iron. Experiment 5. Depth of bar, 1.006 Breadth of do. 1.009 Distance between supports, 2 ft. 3 in.	Weight in lbs.	Deflection in inches.	Permanent Set.	Temp. Fahr.
	112	.037	..	85°
	224	.077	+	
	336	.123	.007	
	448	.170	.013	
	560	.223	.022	
	672	.277	.031	84°
	784	.348	.051	
	896	(.419)	broke	

Broken in water.

Results reduced to those of bars 1.00 *in. square, and* 2 *ft.* 3 *in. between supports.*

	Temp.	Specific gravity.	Modulus of elasticity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 1st, No. 2 Iron	16°	6.968	15538300	800.29	.3865	309.3
Experiment 2nd, No. 2 Iron	24°	..	14267500	823·10	.4140	340.8
Mean,		6.968	14902900	811.69	.4002	325.0
Experiment 3rd, No. 2 Iron	32°	6.968	13723500	933.4	.436	406.9
Experiment 4th, No. 2 Iron	32°	..	14283200	906.0	.423	383.2
Mean,		6.968	14003350	919.7	.429	395.0
Experiment 5th, No. 2 Iron	84°	6.968	14500000	877.5	.421	369.4

The infusion of heat into a metallic substance may render it more ductile, and probably less rigid in its nature; and I apprehend it will be found weaker, and less secure under the effects of heavy strain. This is observable to a considerable extent in the experiments ranging from 26° up to 190° of temperature.

The cold blast at 26° and 190°, is in strength as 874 : 743,
The hot blast at 21° and 190°, is in strength as 811 : 731;

being a diminution in strength as 100 : 85 for the cold blast, and 100 : 90 for the hot blast, or 15 per cent. loss of strength in the cold blast, and 10 per cent. in the hot blast.

TABLE XVII. Coed-Talon Cold Blast.

To determine the relative strengths of Coed-Talon hot and cold blast iron to resist the transverse strain under different degrees of temperature.

No. 2 Iron. Experiment 6. Depth of bar, 1.030 Breadth of do. 1.030 Distance between supports 2 ft. 3 in.			No. 3 Iron. Experiment 7. Depth bar, .995 Breadth 1.005 Distance between supports, 2ft. 3in.		No. 3 Iron. Experiment 9. Depth bar, 1.015 Breadth 1.021 Distance between supports, 2ft 3in.		No. 2 Iron. Experiment 11. Depth bar, 1.004 Breadth 1.005 Distance between supports, 2ft 3in.	No. 2 Iron. Experiment 12. Depth bar, 1.026 Breadth 1.030 Distance between supports, 2ft. 3in.
Weight in lbs.	Deflection in inches.	Permanent Set.	Temperature Fahrenheit.		Weight in lbs.	Tem	Weight in lbs.	Weight in lbs.
112	.034	..						
224	.069	..						
336	.106	+						
448	.144	.009	193°					
560	.185	.011						
672	.231	.016	191					
784	.281	.021						
812	.293	broke						
Broke in hot water.			Broke in boiling water.		956 broke	600°	672 broke it, after the weight had been on half a minute. The deflection was considerable. The weight was laid on at once. This bar was perceptibly red by daylight.	784 broke. This bar was a deep orange colour in the dark. There was no time to measure the deflection.
			Broke in boiling water.		Broke in melted lead.			
			934 broke	212°	1124 broke	600°		
			Broke in boiling water.		Broke in melted lead.			

No. 3 Iron. Experiment 8. Depth bar, .995 Breadth 1.000 Distance between supports, 2ft. 3in			No. 3 Iron. Experiment 10. Depth bar, .987 Breadth .997 Distance between supports, 2ft 3in.	
Weight in lbs.	Tem		Weight in lbs.	Tem
900 broke	212°		956 broke	600°
Broke in boiling water.			Broke in melted lead.	
934 broke	212°		1124 broke	600°
Broke in boiling water.			Broke in melted lead.	

Coed-Talon No. 3 cold blast iron exhibits greater density in the arrangement of its crystalline texture than the No. 2. Colour a whitish gray, interspersed with a number of minute luminous crystals.

Results reduced to those of bars 1.00 inch square, and 2 feet 3 inches between supports.

	Temperature Fahrenheit.	Modulus of elasticity.	Breaking weight (b).	Ultimate deflection (d).	Product $b \times d$, or power of resisting impact.
Experiment 6 . .	193° — 191°	14398600	743.1	.301	223.7
Experiment 7 . .	212°		905.0		
Experiment 8 . .	212°		944.0		
Mean.			924.5		
Experiment 9 . .	600°		909.0		
Experiment 10 . .	600°		1157.0		
Mean,			1033.		
Experiment 11 .	Red by daylight.		663.3		
Experiment 12 . .	Red in dark.		723.1		

TABLE XVIII. Coed-Talon Hot Blast.

No. 2 Iron. Experiment 6. Depth of bar, 1.007 Breadth of do. 1.009 Distance between supports, 2 ft. 3 in.			No. 2 Iron, Experiment 7. Depth of bar, 1.038 Breadth of do. 1.017 Distance between supports, 2 ft. 3 in.			No. 2 Iron. Experiment 8. Depth of bar, 1.019 Breadth of do. 1.015 Distance between supports, 2 ft. 3 in.			No. 3 Iron. Experiment 9. Depth bar, .993 Breadth do. .991 Distance between Distance between supports, 2ft. 3in.			No. 3 Iron. Experiment 11. Depth bar, .986 Breadth do. .997 Distance between supports, 2ft. 3in.	
Weight in lbs.	Deflection in inches.	Permanent Set.	Weight in lbs.	Deflection in inches.	Permanent Set.	Weight in lbs.	Deflection in inches.	Permanent Set.	Weight in lbs.	Temp. 212°	Temp. 600°	Weight in lbs.	Temp. 600°
112	.041	+	112	.044	+	122	.037	+	800 broke	Broke in boiling water.		889 broke	Broke in melted lead.
224	.082	.006	224	.094	.009	224	.075	.003					
336	.123	.010	336	.142	.012	336	.115	.005					
448	.164	.017	448	.198	.016	448	.151	.010					
560	.215	.021	560	.263	.026	560	.205	.018					
672	.271	.036	672	.333	.041	672	.255	.024					
784	.329	.051	700		broke	784	.314	.038					
896		broke				868	broke						
∴ Ultimate deflection=.386. Broke in hot water.		138°	∴ Ultimate deflection=.346. Broke in hot water.		186°	Temperature Fahrenheit.		196°	No. 3 Iron. Experiment 10. Depth bar, .986 Breadth do. 1.000 Distance between supports, 2ft. 3in.			No. 2 Iron. Experiment 12. Depth bar, 1.034 Breadth do. 1.010 Distance between supports, 2ft. 3in.	
		138			187			195					
		134			broke			190					
						∴ Ultimate deflection=.336. Broke in hot water.			Broke in melted lead.			Weight in lbs.	
									811 broke	600°		896 broke.	
												Bar perceptibly red in the dark.	

This iron presents an appearance of greater ductility and softness than the No. 3, cold blast. From the blue tinge which the fracture exhibits, it is evidently an iron possessing the powers of being worked to a greater degree than the cold blast.

Results reduced to those of bars** 1.00 **inch square, and** 2 **feet** 3 **inches between supports.

	Temperature Fahrenheit.	Modulus of elasticity.	Breaking weight (b)	Ultimate deflection (d).	Product $b \times d$ or power of resisting impact.
Experiment 6, bar No. 2 iron	138° — 134°	13046200	875.7	.389	340.6
Experiment 7, bar No. 2 iron	186 — 188	11012500	638.8	.359	229.3
Experiment 8, bar No. 2 iron	196 — 190	13869500	823.6	.363	298.9
Experiment 9, bar No. 3 iron	212°		818.4		
Experiment 10, bar No. 3 iron	600		834.1		
Experiment 11, bar No. 3 iron	600		917.5		
Mean,			875.8		
Experiment 12, bar No. 2 iron	Red in dark		829.7		

In pursuing the experiments, it unfortunately occurred that the stock of No. 2 Coed-Talon metal became exhausted, a circumstance which interrupts the comparisons from below the freezing point to that of melted lead. The No. 3 should have been broken at all the points of temperature, in order to have ascertained the loss of strength sustained upon this iron by the increase of heat. This was, however, not accomplished, and we can now only compare the two qualities, No. 2 and No. 3, at the boiling point of water, and then proceed to the temperature of melted lead. I have already noticed that a considerable failure of the strength took place after heating the No. 2 iron from 26° to 190°. At 212° we have, in the No. 3, a much greater weight sustained than what is indicated by the No. 2 at 190°; and at 600° there appears in both hot and cold blast the anomaly of increased strength as the temperature is advanced from boiling water to melted lead, arising from the greater strength of the No. 3 iron.

A number of the experiments made on No. 3 iron of different sorts have given extraordinary and not unfrequently unexpected results. Generally speaking it is an iron of an irregular character, and presents less uniformity in its texture than either the first or second qualities; in other respects it is more retentive, and is often used for giving strength and tenacity to the finer metals.

Recurring to the No. 2 iron, it will be observed that the strength continued to diminish as the temperature was increased. Heating the cold blast iron in Experiments 11 and 12 to a perceptibly red colour, we have the breaking weights 663 and 723; whereas, in the hot blast, at nearly the same temperature, the breaking weight is 829.7, being as 693 (the mean) to 829, or in the ratio of 1000 : 1289.

From the experiments in Table 1, it appears that a bar of cold blast iron 1 inch square and 2 feet 3 inches between the supports, broke at the ordinary temperature of the atmosphere with 836.9, and in No. 3 cold blast from Table III, the breaking weight is 1137.3. This gives an excess of strength for the No. 3 iron of at least one-fourth.

When the bars were heated to a blood red the utmost care was taken to break them without loss of time. In every instance the deflection was considerable; rather more than 1½ inches was observed on the 2 feet 3 inches bars before they gave way.

Comparative strength and power to resist impact of the Coed-Talon hot and cold blast irons, at various temperatures.

Transverse Strengths.

Temperature.	Coed-Talon Cold Blast.	Coed-Talon Hot Blast.	Ratio.
Fahrenheit.	No. 2 Iron.	No. 2 Iron.	
26°	851.	823.1	1000 : 967.2
32	940.7 } Mean 958.5 } 949.6	933.4 } Mean 906.0 } 919.7	1000 : 977.6
190	743.1	823.6	1000 : 110.8
Red in dark	723.1	829.7	
	No. 3 Iron.	No. 3 Iron.	
212	905.0 } Mean 943.6 } 924.3	818.4 834.1 } Mean	1000 : 885.4
600	909.3 } 1157.0 } 1033.1	917.5 } 875.8	1000 : 847.7

Power to resist impact.

Temperature.	Coed-Talon Cold Blast.	Coed-Talon Hot Blast.	Ratio.
Fahrenheit.	No. 2 Iron.	No. 2 Iron.	
26°	349.8	340.8	1000 : 974
32	360.3 } Mean 404.5 } 382.4	406.9 } Mean 383.2 } 395.0	1000 : 1032
190	223.7	298.9	1000 : 1336

Modulus of elasticity in lbs, for a base of 1 inch square.

Temperature.	Coed-Talon Cold Blast.	Coed-Talon Hot Blast.
Fahrenheit.	No. 2 Iron.	No. 2 Iron.
26°	12994400	14267500
32	13506700 } Mean 15148200 } 14327450	13723500 } Mean 14283200 } 14003350
190	14398600	13869500

The above summary of results on the strength of the hot and cold blast irons is, with one exception, in favour of the cold blast. On the other hand, the power to resist impact appears, with one exception, also, on the side of the hot blast.

Having prosecuted these inquiries through a considerable range both of time and temperature, and having united my efforts to those of Mr. Hodgkinson on the transverse strain, I shall, before closing this report, give a general summary, with the results of which he has kindly favoured me, from all the irons exprimented upon in this way.

Those results will exhibit in one column the relative and proportionate strength of each iron, and in the other the ratio of the forces to resist impact. Before closing the experiments, it may, however, be proper to state, in addition to the methods described in the preceding inquiry, that of grinding was adopted. For this purpose, an apparatus was made to grind each iron under an equal pressure, in order to ascertain the comparative resistances of different specimens of the same size, as compared with the results from chipping and filing given before. This was done with equal weights, upon

equal sections, and during equal periods of time; and each piece was carefully weighed, in order to determine which of the irons was most easily reduced. Notwithstanding the care taken to ensure correct results, I was unable to procure data from which any thing satisfactory could be obtained. For instance, in the Coed-Talon, Elsicar, and Milton irons, each specimen (nearly cubical) was reduced, as in the Table below, where W is a constant weight.

	Weight before grinding.	Weight after grinding.	Loss.
	Grains.	Grains.	Grains.
Coed-Talon No. 2 cold blast iron . . .	W + 56	W — 161	217
Coed-Talon No. 2 hot blast do. . .	W + 264	W + 128	136
Elsicar cold blast do. . . .	W + 155	W + 14	141
Milton hot blast do. . .	W + 211	W + 78	133

The above results, selected from upwards of fifty experiments, are given, not for the purpose of comparison, but in order to enable others to follow up the experiments with greater success. I am of opinion that something may be done in this way; providing cast-steel cutters are used instead of a grindstone, the interstices of which become filled with metallic particles during the process, as the specimens are reduced; consequently the surface of the stone becomes smoother, and the angular points blunted.

General summary of results, as derived from the experiments on the transverse strength of hot and cold blast iron.

			Ratio of strength, that of the cold blast being represented by 1000.	Ratio of powers to sustain impact; (cold blast being 1000.)
These irons are from Mr. Hogdkinson's experiments.	Carron iron,	No. 2	1000 : 990.9	1000 : 1003.1
	Devon do.	No. 3	1000 : 1416.9	1000 : 2785.6
	Buffery do.	No. 1	1000 : 930.7	1000 : 962.1
	Coed-Talon do.	No. 2	1000 : 1007	1000 : 1234
	Coed-Talon do.	No. 3	1000 : 927	1000 : 925
	Elsicar and Milton do.		1000 : 818	1000 : 875
	Carron do.	No. 3	1000 : 1181	1000 : 1201
	Muirkirk do.	No. 1	1000 : 927	1000 : 823
		Mean,	1000 : 1024.8	1000 : 1226.3

The ultimatum of our inquiries made in this way, stand, therefore, in the ratio of strength, as 1000 for the cold blast, to 1024.8 for the hot blast; leaving the small fractional difference of 24.8 in favour of the hot blast.*

The relative powers to sustain impact are likewise in favour of the hot blast, being in the ratio of 1000 to 1226.3.

For the ratios of the powers of the hot and cold blast irons to resist a transverse strain for an indefinite period of time, and for the resisting powers of the same iron under variable temperatures, I must refer the reader to the results contained in their respective tables.

Engravings in Relief from Copperplates by means of Voltaic Electricity.

We lately published (No. 624) M. Jacobi's letter to Mr. Faraday, in

* The extraordinary properties of the Devon No. 3 iron in a great measure account for the difference which occurs between the strengths, as also the comparative powers to resist impact.

which he described his attempts to copy in relief engraved copperplates, by means of voltaic electricity. We have since received a communication from Mr. Thomas Spencer, of Liverpool, from which it appears, that that gentleman has for some time been independently engaged on the same subject; and that he has not only succeeded in doing all that M. Jacobi has done, but has successfully overcome those difficulties which arrested the progress of the latter. It is unnecessary here to enter on the question of priority between these gentlemen. To Mr. Spencer much credit is certainly due for having investigated, and successfully carried out, an application of voltaic electricity, the value of which can hardly be questioned. The objects which Mr. Spencer says he proposed to effect, were the following:—"To engrave in relief upon a plate of copper—to deposit a voltaic copperplate, having the lines in relief—to obtain a fac-simile of a medal, reverse or obverse, or of a bronze cast—to obtain a voltaic impression from plaster or clay—and to multiply the number of already engraved copperplates." The results which he has obtained are very beautiful; and some copies of medals which he has forwarded to us are remarkably sharp and distinct, particularly the letters, which have all the appearance of having been struck by a die.

Without entering into a detail of the steps by which Mr. Spencer brought his process to perfection, many of which are interesting, as showing how slight a cause may modify the result, we shall at once give a description of his process.

Take a plate of copper, such as is used by an engraver; solder a piece of copper wire to the back part of it, and then give it a coat of wax—this is best done by heating the plate as well as the wax—then write or draw the design on the wax with a black lead pencil or a point. The wax must now be cut through with a graver or steel point, taking special care that the copper is thoroughly exposed in every line. The shape of the tool or graver employed must be such that the lines made are not V-shaped, but as nearly as possible with parallel sides. The plate should next be immersed in dilute nitric acid,—say three parts water to one acid: it will at once be seen whether it is strong enough, by the green colour of the solution and the bubbles of nitrous gas evolved from the copper. Let the plate remain in it long enough for the exposed lines to get slightly corroded, so that any minute portions of wax which might remain may be removed. The plate thus prepared is then placed in a trough separated into two divisions by a porous partition of plaster of Paris or earthenware,—the one division being filled with a saturated solution of sulphate of copper, and the other with a saline or acid solution. The plate to be engraved is placed in the divison containing the solution of the sulphate of copper, and a plate of zinc of equal size is placed in the other division. A metalic connexion is then made between the copper and zinc plates, by means of the copper wire soldered to the former; and the voltaic circle is thus completed. The apparatus is then left for some days. As the zinc dissolves, metallic copper is precipitated from the solution of the sulphate on the copper plate, wherever the varnish has been removed by the engraving tool. After the voltaic copper has been deposited in the lines engraved in the wax, the surface of it will be found to be more or less rough, according to the quickness of the action. To remedy this, rub the surface with a piece of smooth flag or pumice-stone with water. Then heat the plate, and wash off the wax ground with spirits of turpentine and a brush. The plate is now ready to be printed from at an ordinary press.

In this process, care must be taken that the surface of the copper in the

lines be perfectly clean, as otherwise the deposited copper will not adhere with any force, but is easily detached when the wax is removed. It is in order to ensure this perfect cleanness of the copper, that it is immersed in dilute nitric acid. Another cause of imperfect adhesion of the deposited copper, which Mr. Spencer has pointed out, is the presence of a minute portion of some other metal, such as lead, which, by being precipitated before the copper, forms a thin film, which prevents the adhesion of the subsequently deposited copper. This circumstance may, however, be turned to advantage in some of the other applications of Mr. Spencer's process, where it is desirable to prevent the adhesion of the deposited copper.

In copying a coin or medal, Mr. Spencer describes two methods: the one is by depositing voltaic copper on the surface of the medal, and thus forming a mould, from which fac-similes of the original medal may readily be obtained by precipitating copper into it. The other is even more expeditious. Two pieces of clean milled sheet lead are taken, and the medal being placed between them, the whole is subjected to pressure in a screw press, and a complete mould of both sides is thus formed in the lead, showing the most delicate lines perfect (in reverse). Twenty, or even a hundred of these, may be so formed on a sheet of lead, and the copper deposited by the voltaic process with the greatest facility. Those portions of the surface of the lead which are between the moulds, may be varnished to prevent the deposition of the copper, or a whole sheet of voltaic copper having been deposited, the medals may afterwards be cut out. When copper is to be deposited on a copper mould or medal, care must be taken to prevent the metal deposited adhering. This Mr. Spencer effects by heating the medal, and rubbing a small portion of wax over it. This wax is then wiped off, a sufficient portion always remaining to prevent adhesion.

Enough has been said to enable any one to repeat and follow up Mr. Spencer's interesting experiments. The variations, modifications, and adaptations of them are endless, and many new ones will naturally suggest themselves to every scientific reader; and for their gratification, the medals produced by this process, and forwarded to us by Mr. Spencer, will be left with our publisher for some days, and open to inspection. Athenæum.

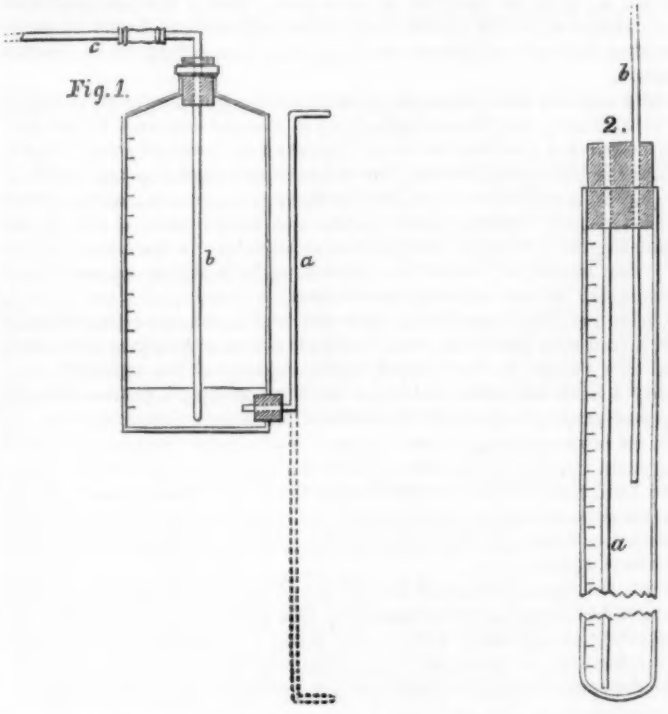
ARTICLES FROM THE FRENCH JOURNALS. TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE, BY J. GRISCOM.

Description of two instruments for finding and determining the Gases that issue from the ground; and the Carbonic Acid of Mineral Waters. By H. ABICH.

To remedy the difficulty experienced in ascertaining the escape of elastic fluids from Solfaterras, Volcanoes, Marshes, &c., and to collect the gases from all such localities, without any access of atmospheric air, the author recommends the following apparatus. A strong glass bottle, fig 1, as cylindrical as possible, is perforated in the side near the bottom. A cork is made to fit this opening very accurately, through which passes a tube, *a*, twice bent at right angles, as in the figure. The upper angle is on a level with the lower part of the cork which closes the neck of the bottle. The tube *b* which passes through the cork in the neck descends to the bottom of the bottle, while to its outer end is adapted a gum elastic tube to facilitate a juncture with a prolonged and bent tube *c*. This tube *c* may be pressed deeply into the ground or opening to receive the gas, or it may be connected

with a funnel for its more rapid collection. As soon as the gas is found to escape through this tube freely, it may be joined to *b*, and by turning the tube *a* downwards (as represented by the dotted lines) the water or mercury will flow out as the gas enters, and its access may be immediately stopped by raising *a* to its former position. The tube *c* may be disengaged without risk of an escape of the gas, as long as *b* remains covered at bottom by a sufficient depth of fluid.

Fig. 1.



It will be readily understood that by means of a graduated tube or flask and a little pneumatic mercurial apparatus, formed of a capsule of hard wood, even the quantitative analysis of a mixture of gasses may be easily made on the spot. The quantity of carbonic acid, for example, (if it be not mixed with other gases absorbable by potash) may be determined by collecting the gas over mercury, and after placing the graduated flask in the capsule of mercury, cutting the tube very near the bottom, to observe the absorption of the carbonic acid whose volume is immediately announced by the scale of the bottle itself.

When solutions of reagents are used in the bottle for collecting the gas, the apparatus becomes still more appropriate for determining the presence of different gases in mixture. It is easy to increase the amount of the precipitate by passing fresh volumes of the gas through the liquid, and I am persuaded that in this way approximate conclusions may be made of the quantity of certain gases in a given volume of the mixture.

By the aid of this little apparatus I have often satisfied myself of the

presence of carbonic, hydrochloric, sulphuric, and hydrocyanic acids in the vapours of places where the common means of collecting gases could have given no satisfactory result. Hence I may venture to recommend the instrument to travelling geologists, who can seldom carry with them, conveniently, any complicated apparatus. Two or three bottles adjusted as above, a few tubes of different diameters, previously bent and drawn to a fine point, to be enlarged or hermetically closed by the blow pipe as occasion requires, a bottle of distilled or rain water, and a few concentrated solutions of reagents, are in almost every case sufficient, and may be transported without difficulty to places which promise a rich field for researches of this nature.

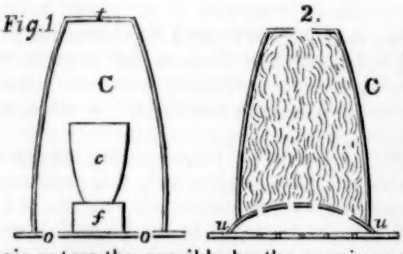
I will here add the description of an instrument which I have successfully used for determining the free carbonic acid in mineral waters. If not perfect in all its parts it enables one to precipitate very promptly and simply, and without the least possible loss, the carbonic acid in the spring itself. A cylinder (fig. 2) of sufficient width, is carefully graduated and nicely closed by a well fitted cork, through which passes two open tubes, *a* and *b*, the first terminating at the top of the cork and descending to the bottom of the cylinder; the second of about the same length, movable up and down through the cork, without allowing air to pass.

Learn, from previous experiment, how much of a solution of the chloride of barytes mixed with ammonia, must be employed to precipitate all the carbonic acid in a volume of water equal to the capacity of the cylinder.

A qantity a little more than sufficient for this purpose, is poured into the cylinder, and exactly measured by means of the scale; then withdraw the tube *b* till its lower opening is near the cork, and plunge the instrument into the spring until the end of the tube is just even with the surface of the water. When the fluid rises in the cylinder to the lower end of the tube *b*, all the free carbonic acid, as also the alkaline and earthy carbonates and bicarbonates contained in the water will be perfectly precipitated without the loss of the least portion of them.

Withdraw the instrument, and let the precipitate subside; then separate it by filtration and keep it, for examination, in a ground stoppered vial. It is hardly necessary to add that it must be the object of a separate analysis to determine the quantity of carbonates and bicarbonates in the water, to be able to correct the carbonic acid obtained by the precipitate. Ann. de Chemie.

An easy method of using a common Furnace as a muffle Furnace. By Gay Lussac.



Let C, (fig. 1) be a common crucible at the bottom of which a little hole *t* is pierced. It may serve for a muffle on many occasions.

If a calcination is to be performed in a small crucible, *c*, place it on a little earthen block *f*, and cover it with the crucible C. Place them on the grate of a furnace, and urge the fire as it may be necessary. The air enters the crucible by the openings *o*, *o*, of the grate, and escapes by the upper hole *t*, so that the vitiated air is constantly removed by fresh air. To obtain a high temperature, the crucible C may be covered with char-

coal, but then a fragment of crucible must loosely cover the hole *t*, to keep out charcoal dust, &c.

If copper turnings are to be oxydized for the purpose of organic analyses, the crucible C, (fig. 2) is filled with the turnings; the crucible covered with a convex dish *u*, *u*, pierced with four or five little holes by the point of a nail, the crucible is luted to the dish, and then inverted on the grate of the furnace. By bringing the crucible to a dull red heat, the copper is rapidly oxydated.

These two examples are sufficient to show the uses of this new kind of muffle. Ibid.

New Apparatus for measuring very promptly the relative Refraction of Liquids.

This apparatus is composed of a converging lens placed on a plate of glass with a space between the two to be filled by the liquid. A very simple formula gives the relative refraction of the liquid, after observing, 1st, the focus of the apparatus when water is interposed; 2nd, the focus when the water is replaced by the liquid in question. The instrument is destined principally to shew the chemical properties of liquids, and thus to serve in some measure as a re-agent in the laboratory. For example M. Guérin suspected that if two equally concentrated solutions of tartaric and paratartaric acid were subjected to examination, a difference of refractive power might be found between these two isomeric acids. The apparatus is simple and the calculation from the observed difference very easy. l'Institute, No. 287.

Leveling between the Black and Caspian Seas.

M. Fuss in a note on the accumulation of errors in the final results of the geodesic levelling between the two seas, endeavoured to show that the method of observing two signals by placing one's self in the middle point of the space between them, can give accurate results only when care is taken to make daily but a finite series of observations and to alternate them in the same order as that in which they are made. He showed to what an extent errors might accumulate, for want of this precaution, in the definitive result of the levelling between these two seas, in which a difference of level has been found of 1045.2 English inches, a result which, by discarding doubtful observations, is reduced to 995.2 inches, while the method by corresponding observations furnished only 887.1 inches. But by applying to the first result the correction for the accumulation of errors arising from the neglect of the condition which ought to have been regarded in observing two signals from the middle of their distance, the amount was reduced to 902.5 inches, which differs from that obtained by corresponding observations only by 25.4 inches. When this correction is made, we may then seek by the calculation of probabilities the weight of these two results, and deduce from them the probable definitive value of the exact depression of the Caspian Sea. Ibid.

Formation of Silk. By M. H. Straus—Durckheim.

It is generally admitted by naturalists that the thread of the caterpillar is produced by a simple emission of liquid matter through the orifice of the

spinner, and that it acquires solidity at once from the drying influence of the air. It was easy to imagine such an hypothesis, for nothing more simple than the formation of a very fine thread by such a process. But a little reflection will soon show us, even *à priori* that it is not possible; for how can we comprehend that so fine a fibre, liquid at the instant of its issue from the aperture should immediately acquire such a consistence as to bear the weight of the animal suspended by it, and at the same time that it is rapidly produced. Though the fluid, holding the silk in solution, should be quickly volatilised, it must still be a matter of conjecture how the animal suspended by this thread could be able to arrest its issue, holding on only by the thread itself, for it cannot pinch the thread, seeing that it is only in a liquid state inside, and the thread cannot be glued to the edge of the opening, for its rapid adherence would prevent its issue while the animal is spinning. A little examination would satisfy us that silk cannot be produced in this manner, but that it is *secreted in the form of silk* in the silk vessels, and that the spinning apparatus only winds it. The thread is produced in the slender posterior part of the vessel, the inflated portion of which is the reservoir of ready formed silk, where it is found in the form of a skein, each thread being rolled up so as to occupy in the silk worm *(Bombex mori)* a space of only about a sixth part of the real length of the skein. The fact is shown by the following experiment which I made for the purpose of ascertaining whether the silk is formed in the body of the caterpillars.

Take one of the animals when about to form its cocoon, clean it in common vinegar, in which it may remain from four to six hours, open it on the back and extract the silk vessels, there being one on each side of the alimentary canal. Take them up by the hinder end, just where they begin to swell, (further back the silk is not solid enough) and draw them out. The membrane forming the vessel is easily torn open, and the contents expand to six or seven times its original length. The skein having attained its full length by the letting out of its gathers, we obtain a cord perfectly equal in size throughout, except at the end, where it is attenuated. This cord resembles a large horsehair, and constitutes what fishermen call *Florence hair*. I ought to add that in simply drawing out the silk vessel, the Florence hair is found enveloped in a golden-yellow gummy matter, forming the glutinous portion by which the worm fastens its thread. This must be got rid of by drawing the cord through the fold formed on the inside of the joint of the left fore finger, converted into a canal by applying to it the end of the thumb. The glutinous substance and the membranes being thus separated, we have the naked hair. In this state, before the silk becomes dry and hard, not only will it be indefinitely divided longitudinally, which proves its fibrous structure, but in trying to split it by drawing it transversely, the little filaments of silk which form it are perfectly separated, forming a bundle of extremely fine fibrils. Ibid. No. 291.

Progress of Civil Engineering.

Locomotive Excavator.

M. Gervais, a manufacturer of Caen, and a member of the Superior Council of Commerce, has lately presented to the Academy of Science a small model of a locomotive excavator, (Terassier Locomoteur). This machine may be usefully employed in the excavation of canals and formation

of railroads; but from the want of strength in its construction, it seems at present suitable only to an alluvial soil. A force of steam of from two to three horse power is required to work it; it clears a space eight feet (2m. 50) wide, and 2 ft. 3 in. (0m. 70) deep, and advances 1 ft. 3 in. (0m. 38) a minute. Thus, in twenty-four hours it completes 1800 feet (547m. 20) in length; having cleared out 3250 feet (1000 cubic metres) of earth, which is levelled as regularly on each bank as it could be done by the hands of man. The expense in twenty-four hours cannot exceed 40 francs. The clearing of a cubic metre of earth, therefore, costs abouts 4 centimes. If we compare this with the price usually paid, the advantage of the invention is evident; but this is nothing in comparison with the advantages which we may expect to derive from the great saving of manual labour, and from the rapid increase of works so beneficial to the industry of the country.

The inventor's first idea was to employ men in levelling all occasional elevations beyond fifteen inches (0m. 40), but it was found less expensive to employ the machine used in cutting railrods. His plan proceeds on the same principle. The same frame which carries the locomotive, is arranged so that tools, attached to it, can work upwards from the surface of the earth, instead of downwards, and thus remove these elevations. A space is levelled equal in width to the working of the locomotive excavator, and then rails are laid down to preserve the direction and the level. The locomotive follows, excavating and throwing out the earth either on one or both of the banks, and forming an inclined plane, on each side, of forty-five degrees. If a canal is required to be sixteen feet (five metres) deep, or deeper, and cannot be excavated at once, there is attached to the machine behind, an axletree, and cast-iron wheels with large felloes, by which means, as fast as the first cutting is finished, lines are traced on which to place the rails for the second, and so as to preserve the original level. A machine capable of working twenty feet wide, and eight feet deep, excavates sixteen cubic feet of earth in a minute.

In railroads, the process would be nearly the same as in canals, except that the inclined plane on the sides need be only of fifteen degrees, and the earth might be carried away by carts wherever is was wanted. This machine is calculated for light and sandy soils; and is so constructed, that, should it encounter any obstacle, it may be stopped in a moment to prevent accidents. Thus, any rocky substance, if small, can be lifted up; if large, can be broken to pieces by the workmen, and carried away on the frame of the machine, after removing the tools, which can then be replaced, and the work continued.

It would be difficult to give a more particular detail without the aid of the plan, which the inventor has transmitted to the academy for the use of the committee, who, as well as ourselves, have seen the machine at work. Whatever their decision may be, it seems to us that the only question now, is the application of steam to the excavation of canals and railroads. The employment of this machine on a large scale, must be attended with great advantages, whether we consider the difficulty of collecting a considerable number of workmen on one spot, the increased rapidity of the work, or the improved salubrity of low grounds by the draining of marshes, and the removal of miasma and its consequent diseases. And these great advantages, if the machine of M. Gervais can really be employed on a large scale, are to be obtained at a remarkably small expense. Taking the model, which we have seen at work, as our data, if we calculate on a three horse power steam-engine, and a consumption of 15 kilogrammes (30 lbs.) of coal per hour, we

shall find, after deducting 30 per cent. interest for the outlay, and making every allowance for repairs, and loss of time when the machine is not at work, that it can excavate 957 cubic metres of earth at a cost of 48 francs 50 cents; whereas we now pay for excavating the same quantity, 478 francs 50 cents. In short, the invention of M. Gervais bids fair to make a great revolution in the mode of excavation, and we look forward with a degree of impatience for the decision of the committee of the academy.—*Inventors' Advocate.*

Mining Rev.

Description of a Machine called a Floating Clough. By GEORGE ELLIS, *Grad. Inst. C. E.*

The machine here described is used for scouring a channel which leads from the Winestead Drainage and Haven of Pattrington, into the river Humber. It is constructed in the following manner:—The frame is made of timbers six inches by four, twelve feet long, nine wide, and six deep. This frame is covered with planking two inches thick, and through the middle of it a culvert is formed with planks, two feet six inches in width, with a small lifting door at one end. Connected with the bottom and projecting in front are two long beams called feelers, which keep the machine in its course, and in the front are frames of wood shod with rough iron like the teeth of a saw, and these are connected with racks which can be raised by a lever.

At each side of the machine there is a wing which is made to fit the slope of the banks, to dress the mud from the sides, and to keep up the water behind the machine.

At high tide the machine is moored in the middle of the channel, the wings are extended and kept so by ropes, and when the tide is at half ebb the plugs are taken out, and the water rises about two feet in the machine, which causes it to sink; the plugs are replaced, and thus it remains till full ebb, when the iron-shod frames are let down in front, and the tide forces the whole machine, which is like a great dam, gently down the stream, scraping with it all the mud down to the river, where it is emptied, and floated back with the return tide. The whole distance, about three miles, is performed in two hours. A machine of the same kind is used with great advantage at Great Grimsby.

Proceed. Inst. Civil Eng.

Description of a Sawing Machine for cutting off Railway Bars. By JOSEPH GLYNN, *M. Inst. C. E.*

The advantage of having the ends of the railway bars cut as nearly square as possible, that they may truly abut against each other, is so great, that many attempts have been made to effect it. The author in this communication describes the method which is adopted at the Butterly Works in the manufacture of the rails for the Midland Counties Railway. In general the ends, rough and ragged as they come from the rolls, are separately reheated and cut off by the circular saw, but the accuracy in this case depends on the workmen presenting the bar at right angles to the plane of the saw. As this cannot be insured, the difficulty may be obviated as follows. The axis of the saws and the bed of the machine, which is exactly like that of a slide lathe, are placed at right angles with the line of the rolls in which the rails are made; the saws are fixed in headstocks and slide upon the bed, so as to adjust them for cutting the rails to the exact length, and are three

feet in diameter and one-eighth of an inch thick, with teeth of the usual size in circular saws for wood, and make one thousand revolutions per minute; the teeth are in contact with the hot iron too short a period to receive any damage, but to prevent all risk the lower edge of the saw dips in a cup of water. The saw plate is secured between two discs of cast iron faced with copper and exposed only at the part necessary for cutting through the rail. The rail on leaving the rolls is hastily straightened with wooden mallets on a cast-iron plate, on which it lies right for sawing and sufficiently hot; thus a considerable saving of time, labour, and heat, is effected. The rail is brought into contact at the same time with the two saws, and both ends are cut off by one operation. If the saws be sharp and the iron hot, the seventy eight pound rails are cut through in twelve seconds. The rail on leaving the saws is placed in a groove planed in a thick cast-iron plate; thus all warping is prevented. The author then describes certain mechanical arrangements, which are exhibited in detail in the drawing accompanying the communication. Ibid.

On Framing Lock Gates without Iron Work. By S. Ballard, *A. Inst. C. E.*

The ledges, or horizontal pieces, are held to the back and mitre post by dovetail tenons and wedges; thus avoiding the use of iron T pieces and screw pins, which occasion the wood in immediate contact with them to decay, while the parts not pierced with iron are perfectly sound. This method was adopted in some gates on the Herefordshire and Gloucestershire canal, and after some years' experience, is found completely successful. Tar and white lead are put into the mortices, and the wedge driven down upon it, so that every crevice is filled, and the joints rendered water-tight; the planks, also, are fastened on with oak pins instead of nails.

Some discussion took place on the general opinion, that when dissimilar substances are in contact, as when a gate of one kind of wood is fastened with pins of another wood, some action tending to loosen the pins prematurely takes place betwixt them. Ibid.

LUNAR OCCULTATIONS FOR PHILADELPHIA, MARCH, 1840.

Angles reckoned to the right or westward round the circle, as seen in an inverting telescope. ☞ For direct vision add 180° ☜

Day.	H'r.	Min.	Star's name.	Mag.	from Moon's North point.	from Moon's Vertex.
18	9	24	Im. χ Virginis	6	337°	297°
18	9	39	Em.		311	272

Meteorological Observations for September, 1839.

Moon.	Days	Therm. Sun rise.	Therm. 2 P.M.	Barometer. Sun rise.	Barometer. 2 P.M.	Wind. Direction.	Wind. Force.	Water fallen in rain.	State of the weather, and Remarks.
				Inch's	Inch's			Inches.	
	1	56	72	30.15	30 20	N.E.	Moderate.		Lightly cloudy—clear.
	2	56	74	.20	.20	W.	do.		Clear—do.
	3	54	72	.15	.15	N.E.	do.		Clear—cloudy—aurora.
	4	62	69	.04	.00	E.	do.	.40	Cloudy—rain.
	5	62	70	29.80	29 80	W.	do.		Cloudy—do.
	6	65	77	.83	.80	S.W.	do.	.11	Cloudy—showery.
⊗	7	66	76	.75	.75	S.W.	do.		Fog—cloudy
	8	70	72	.65	.60	S.E.	do.	.24	Rain—do.
	9	72	82	.65	.64	S.W.	Brisk.		Cloudy—clear.
	10	66	74	.75	.75	W.	do.		Clear—do.
	11	64	67	.83	.83	W.	do.		Clear—do.
	12	56	67	.90	.90	W.	Calm.		Clear—flying clouds.
	13	53	67	.90	.93	N.N.E.	Moderate.		Flying clouds—clear.
☾	14	45	70	30.10	30.10	W.	do.		Clear—do.
	15	46	69	.16	.16	W.	do.		Clear—do.
	16	54	70	.05	.15	S.W.	do.		Fog—clear.
	17	54	74	.03	.00	S E.	do.		Fog—flying clouds.
	18	65	73	29.75	29.70	S.	do.	1.00	Rain—thunder shower with hail.
	19	58	72	.80	.83	S W.	do.		Clear—do.
	20	56	75	.90	.95	S.W.	do.		Clear—do.
	21	60	77	.90	.95	W.	do.		Lightly cloudy—clear.
	22	62	77	.90	.85	W.	Brisk.		Fog—clear.
⊙	23	62	72	.65	.65	W.	Moderate.		Clear—cloudy.
	24	55	71	.65	.95	S.W.	do.		Clear—do.
	25	55	72	.65	.55	S.	do.	.9	Clear—rain.
	26	52	60	.60	.75	S.W.	Brisk.		Cloudy—clear.
	27	44	66	.95	.80	W.	do.	.10	Clear—rain.
	28	42	54	.90	.96	W.	Moderate.		Clear—do.
☽	29	42	60	30 00	30.00	W.	do.		Lightly cloudy—clear.
	30	47	52	.05	.10	N.E.	do.		Cloudy—do.
	Mean	56.70	69.77	29.89	29.90			1.94	

	Thermometer.		Barometer.
Maximum height during the month.	82 00	on 9th.	30.20 on 1st. & 2nd.
Minimum " "	42 00	28th. & 29th.	29.55 25th.
Mean	63.235.		29.895

OCTOBER 1839.

Moon.	Days	Therm. Sun rise.	Therm. 2 P.M.	Barometer. Sun rise.	Barometer. 2 P.M.	Wind. Direction.	Wind. Force.	Water fallen in rain.	State of the weather, and Remarks.
				Inch's	Inch's			Inches.	
	1	37	58	30.29	30 22	N.W.	Moderate.		Clear—do.
	2	41	62	.20	.05	S.W.	do.		Clear—do.
	3	50	72	29.90	29.80	S.W.	do.		Lightly cloudy—clear.
	4	56	72	.96	.95	N.W.	do.		Clear—do.
	5	46	57	30.20	30.30	N.E.	Brisk.		Partially cloudy—clear.
⊗	6	44	60	.44	.48	E.	Calm.		Clear—do.
	7	45	61	.45	.37	N.W.	do.		Cloudy—do.
	8	49	68	.16	.03	N.W.	do.		Clear—do.
	9	51	71	.30	29.95	S.W.	do		Lightly cloudy—hazy.
	10	54	70	29.90	.90	S W.	do.		Lightly cloudy—do.
	11	54	66	0.10	30.00	N.E S.E.	do.		Clear—do.
	12	56	59	.05	29.95	E.	do.	.14	Cloudy—rain.
	13	60	68	29.80	.80	S.	do.	.65	Cloudy—rain with thunder.
	14	60	64	.80	.80	N.E.	Moderate.		Cloudy—do.
☾	15	57	61	30 00	30.05	N E.	do.		Cloudy—do.
	16	50	65	.25	.20	W.E.	do.		Clear—do.
	17	54	68	.20	.20	S-W.	do.		Cloudy—clear.
	18	49	70	.16	.16	W.E.	do.		Lightly cloudy—clear.
	19	62	64	29 90	29.80	E.N.E.	do.	1.00	Rain—drizzle.
	20	42	48	30.15	30.30	N.W.	do.		Clear—cloudy.
	21	32	49	.50	.50	N W.	do.		Cloudy—clear.
	22	40	56	.00	29.90	E.W.	do.		Hazy—do.
⊙	23	42	62	29 80	.70	W.S.W.	do.		Hazy—do.
	24	50	71	30.02	.95	W.	do.		Hazy—do.
	25	52	65	.05	30.06	E S.E.	do.		Fog—clear.
	26	48	62	.20	.20	E.S.	do.		Cloudy—clear.
	27	51	65	.10	.05	W.S.	do.		Cloudy—clear.
	28	60	67	29.90	29.85	W.S.	do.		Cloudy—do.
☽	29	46	60	.90	.90	W.	do.		Clear—do.
	30	41	60	.90	.90	W.	do.	.25	Clear—cloudy—rain.
	31	43	56	.63	.66	W.	Calm.		Clear—flying clouds.
	Mean	49.10	63.13	30.06	30.03			2.04	

	Thermometer.		Barometer.
Maximum height during the month.	72.00	on 3rd & 4th.	30.50 on 21st.
Minimum " "	32 0)	21st.	29 63 31st.
Mean.	56,115		30.045

METEOROLOGICAL REPORT

FOR THE STATE OF PENNSYLVANIA,

Collated from returns made to the Committee on Meteorology of the Franklin Institute of the State of Pennsylvania, for

JANUARY, 1840.

	County.	Town.	Observer.	Thermometer. 7, A. M.	2, P. M.	9, P. M.	Maximum.	Minimum.	Mean.	Days omitted.	Register. Lowest.	Mean.	Days omitted.	Barometer. 7, A. M.	2, P. M.
1	Philadelphia,														
2	Montgomery,														
3	Bucks,	Newtown,	L. H. Parsons,	21.38	30.08	22.94	42.00	—2.00	24.80	.	—5.00	17.35	.	30.03	30.0
4	Lehigh,														
5	Northampton,														
6	Monroe,	Stroudsburg,	A. M. Stokes,	12.74	25.83	15.09	45.00	—16.00	17.89	3 1/3	....	....	.	29.49	29.4
7	Pike,														
8	Wayne,														
9	Susquehanna,	Silver Lake,	E. W. Rose,	11.26	20.19	14.71	39.00	—15.00	11.54	.	—17.00	8.74	.	27.89	27.89
10	Luzerne,														
11	Schuylkill,	Port Carbon,	Port Carbon Lyceum,												
12	Berks,	Reading,	C. F. Egelmann,	19.00	25.84	20.81	45.00	0.00	21.88	.	....	....	.	29.83	29.81
13	Chester,														
14	Delaware,	Haverford,	Haverford School,	19.99	28.39	22.90	50.00	4.00	23.76	1/3	4.00	18.90	.	29.50	29.5
15	Lancaster,	Lancaster,	Conservatory of Arts,	20.14	29.98	22.60	48.50	1.00	24.24	.	1.00	18.11	.	29.49	29.47
16	York,														
17	Lebanon,														
18	Dauphin,														
19	Northumberland,	Northumberland,	Andrew C. Huston,	14.72	26.82	12.77	45.00	—21.00	18.10	.	—24.00	9.16	.	29.43	29.41
20	Columbia,														
21	Bradford,														
22	Tioga,														
23	Lycoming,														
24	Union,														
25	Mifflin,														
26	Juniata,	Mifflintown,	J. A. Rinkead,	15.37	30.64	19.72	49.00	—22.00	21.98	.	....	....	.	29.47	29.46
27	Perry,														
28	Cumberland,	Carlisle,	Prof. W. H. Allen,	14.42	28.23	19.42	42.00	—14.00	20.69	.	—14.00	13.65	.	29.39	29.39
29	Adams,	Gettysburg,	Prof. M. Jacobs,	17.88	29.88	21.34	44.00	—13.00	23.04	.	—13.00	15.24	.	29.40	29.37
30	Franklin,														
31	Huntingdon,														
32	Centre,	Bellefonte,	John Harris,	12.42	25.47	17.07	45.00	—27.00	18.32	2/3	—28.00	8.13	8	29.25	29.25
33	Potter,														
34	M'Kean,	Smithport,	Richard Chadwick,	12.71	24.23	18.50	46.00	—24.00	18.48	1/3	—24.00	9.00	1	28.07	28.08
35	Clearfield,														
36	Cambria,	Ebensburgh,	Richard Lewis,	13.90	22.23	17.84	44.00	—10.00	17.99	1/3	—12.00	7.52	9	27.70	27.68
37	Bedford,														
38	Somerset,	Somerset,	George Mowry,	16.50	26.71	21.23	47.00	—22.00	21.48	.	....	....	.	27.81	27.83
39	Indiana,	Indiana,	Richard White,	20.00	26.71	22.06	50.00	—20.00	22.92	.	—15.00	12.30	9	28.55	28.52
40	Jefferson,														
41	Warren,	Warren,	R. Brown,	13.38	27.76	16.71	43.50	—26.00	19.28	.	...	....	.	28.79	28.74
42	Venango,	Franklin,	Wm. Connelly,	11.16	26.48	18.42	53.00	—26.00	18.69	.	....	....	.	....	....
43	Armstrong,														
44	Westmoreland,														
45	Fayette,														
46	Green,														
47	Washington,														
48	Allegheny,														
49	Beaver,														
50	Butler,	Butler,	Jacob Mechling,	10.65	25.76	17.37	46.00	—28.00	17.93	.	....	....	.	....	....
51	Mercer,	West Greenville,	John Keck,	19.40	24.78	24.17	45.00	—20.00	22.78	3 2/3	....	....	.	28.79	28.78
52	Crawford,														
53	Erie,	Erie,	Erie Academy,	19.19	26.71	19.85	44.00	— 1.00	21.92	.	—2.00	16.32	.	29.31	29.33

Meteorological T

Moon.	Days	Therm. Sun rise.	Therm. 2 P.M.	Barometer. Sun rise.	Barometer. 2 P.M.	Meteor-
				Inch's	Inch's	
	1	56	72	30.15	30.2	
	2	56	74	.20	.2	
	3	64	72	.15	.1	
	4	62	60	.04	.0	
	5	62	70	29.80	29.8	
	6	65	77	.83	.8	
⊗	7	66	76	.75	.7	
	8	70	72	.65	.6	
	9	72	82	.65	.6	
	10	66	74	.75	.7	
	11	64	67	.83	.8	
	12	56	67	.90	.9	
	13	53	67	.90	.9	
	14	45	70	30.10	30.1	
☾	15	46	69	.16	.1	
	16	54	70	.05	.0	
	17	54	74	.03	.0	
	18	65	73	29.75	29.7	
	19	58	72	.80	.8	
	20	56	75	.90	.9	
	21	60	77	.90	.9	
	22	62	77	.90	.9	
⊕	23	62	72	.65	.6	
	24	55	71	.65	.6	
	25	55	72	.65	.6	
	26	52	60	.60	.6	
	27	44	66	.95	.9	
	28	42	54	.90	.9	
☽	29	42	60	30.00	30.0	
	30	47	52	.05	.0	
	Mean	56.70	69.77	29.89	29.	

Maximum height during the mon
Minimum " "
Mean

				Inch's	Inch	
	1	37	58	30.29	30.	
	2	41	62	.20	.	
	3	50	72	29.90	29.	
	4	56	72	.96	.	
	5	46	57	30.20	30.	
	6	44	60	.44	.	
⊗	7	45	61	.45	.	
	8	49	68	.16	.	
	9	51	71	.30	29.	
	10	54	70	29.90	.	
	11	54	66	0.10	30.	
	12	56	59	.05	29.	
	13	60	68	29.80	.	
	14	60	64	.80	.	
☾	15	57	61	30.00	30.	
	16	50	65	.25	.	
	17	54	68	.20	.	
	18	49	70	.16	.	
	19	62	64	29.90	29.	
	20	42	48	30.15	30.	
	21	32	49	.50	.	
	22	40	56	.0	29.	
⊕	23	42	62	29.80	.	
	24	50	71	30.02	.	
	25	52	65	.05	30.	
	26	48	64	.20	.	
	27	51	65	.10	.	
	28	60	67	29.90	29	
☽	29	46	60	.90	.	
	30	41	60	.90	.	
	31	43	56	.63	.	
	Mean	49.10	63.13	30.06	30.	

Maximum height during the mo
Minimum "
Mean.

Thermometer.

7, A. M.	2, P. M.	9, P. M.	Maximum.	Minimum.	Mean.	Days omitted.	Register. Lowest.	Register. Mean.

Register.			Barometer.							Weather.							Winds.																Hygrometer.					No. of Report.
Lowest.	Mean.	Days omitted.	7, A. M.	2, P. M.	9, P. M.	Maximum.	Minimum.	Mean.	Days omitted.	Clear.	Cloudy.	Days omitted.	Rain.	Snow.	Rain and Snow.	Thunder Showers.	Rain in inches.	North.	N. N. E.	N. E.	E. N. E.	East.	E. S. E.	S. E.	S. S. E.	South.	S. S. W.	S. W.	W. S. W.	West.	W. N. W.	N. W.	N. N. W.	Calm.	Days omitted.	Dew-point.	Days omitted.	Diff. therm. and dew point.	Wet Bulb.	Days omitted.	
—5.00	17.35	.	30.03	30.01	30.07	30.58	29.28	30.04	.	14	16⅔	⅓	....	....	....	..	.....	⅓	.	4	.	.	.	.	.	.	5⅔	.	⅓	.	20⅔	.	.	.	....	.	.....	....	.	981
....	....	.	29.49	29.48	29 50	30.25	28.75	29.49	2⅓	9⅔	18⅓	2⅔	....	....	....	..	.....	3⅔	.	4⅕	.	1⅓	.	.	.	.	.	2	1⅓	9	3⅕	4⅕	.	.	1⅓	....	.	.....	....	.	959
—17.00	8.74	.	27.89	27·89	27.85	28.50	27.25	27.87	.	11⅓	19⅕	.	....	2	...	..	.800	.	.	.	.	1	.	.	.	1⅓	.	4⅔	.	10⅕	.	4⅓	.	9⅓	.	....	.	.....	....	.	969
....	....	.	29.83	29.81	29.80	30.35	29.12	29.81	.	13⅓	17⅔	.	3	3	1	..	.....	⅓	.	⅔	.	2⅖	2	⅔	.	.	.	⅓	4	5	⅔	15	.	.	.	....	.	.....	....	.	934
4.00	18.90	.	29.50	29.55	29.52	30.13	28·80	29.52	⅔	11	19⅓	⅔	....	....	....	..	1.518	1⅔	⅔	1⅔	.	1	⅕	.	.	1⅕	.	1	1⅔	4⅔	2⅓	10⅓	.	⅔	3⅔	14.40	6	.....	....	.	938
1.00	18.11	.	29.49	29.47	29.50	29.98	28.75	29.49	.	15	16	.	4	5	....	..	2.607	⅔	1⅕	1⅔	1	.	.	4⅓	⅔	⅓	⅓	5	⅓	6	3⅔	4⅓	1⅓	.	.	20.72	1	.....	29.65	1	956
—24.00	9.16	.	29.43	29.41	29.44	29.92	28.68	29.43	.	8⅓	22⅓	⅓	2	8	1	..	2.143	3⅔	.	1	.	2⅔	.	2⅕	⅕	3⅔	.	2⅓	.	6	.	3½	⅓	5⅓	.	....	.	.....	....	.	931
....	....	.	29.47	29.46	29.49	30.00	28.77	29.47	.	12	17⅓	1⅔	....	....	...	..	.....	⅓	.	1⅓	.	1	.	.	.	.	.	2	.	2	.	7	.	17⅓	.	....	.	.....	....	.	937
—14.00	13.65	.	29.39	29.39	29.38	29.90	28.79	29.39		12	19	.	2	5	1	..	2.063	⅕	.	3⅓	.	⅔	.	⅔	.	⅔	⅓	3⅔	⅕	4⅔	1⅔	2⅓	.	12	.	....	.	.....	....	.	935
—13.00	15.24	.	29.40	29.37	29.40	29.89	28.29	29.39	.	12⅔	18⅓	.	6	2	1	..	2.463	3⅔	⅓	1⅓	.	⅓	.	.	.	2⅓	1⅔	2⅔	⅕	7⅔	1⅓	2	⅓	7⅓	.	....	.	.....	....	.	933
—28.00	8.13	8	29.25	29.25	29.29	29.77	28.54	29.26	⅓	8	22⅔	⅓	....	....	....	..	.....	1	.	4	.	⅓	.	1	.	.	.	7⅓	.	8⅓	⅓	7⅓	.	⅓	1	....	.	.....	....	.	966
—24.00	9.00	1	28.07	28·08	28.08	28.90	27.45	28.08	⅔	3⅔	26⅔	⅔	1	4	....	..	1.533	2⅓	.	.	.	2	.	⅓	.	.	.	1	.	13⅓	.	8	.	3⅓	⅔	....	.	.....	31.07	16	957
—12.00	7.32	9	27.70	27.68	27.71	28.16	27.10	27.70	½	6⅔	22⅓	1⅓	3	5	1	..	.....	1	.	⅓	.	⅓	.	1	.	⅔	.	4	.	15⅔	⅕	3	.	4	⅔	....	.	.....	...	.	942
....	....	.	27.81	27.83	27.87	28.36	27.60	27.84	.	7⅓	23⅓	2	11	....	....	..	.....	⅕	2⅓	1⅔	.	⅔	.	.	.	.	.	7	6⅕	4	⅓	2	.	6½	.	....	.	.....	....	.	971
—15.00	12.30	9	28.55	28.52	28.53	29.00	27.90	28.53	.	7⅔	23⅓	5	6	1	....	..	3.141	.	.	.	.	⅔	.	⅓	.	.	.	10⅔	.	⅔	.	5⅔	.	13⅓	.	....	.	.....	....	.	991
...	....	.	28.79	28.74	28.74	29.15	27.50	28.76	.	6	25	.	....	....	...	..	.....	4⅓	.	.	.	⅙	.	1	.	3⅔	.	⅓	.	12	.	⅓	⅓	8⅓	.	....	.	.....	....	.	950
....	....	.	....	....	....	....	....	....	.	7⅔	23⅓	.	3	3	....	..	.....	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	....	.	.....	....	.	940
....	....	.	....	....	....	....	....	....	.	8	23	.	....	10	....	..	.....	.	.	⅔	.	8	.	1⅔	.	.	.	16	.	4	.	⅔	.	.	.	....	.	.....	....	.	936
....	....	.	28·79	28.78	28.78	29.32	28.06	28.78	2⅔	2	12⅓	16⅔	....	....	....	..	.....	10⅔	.	.	.	.	.	.	.	15⅔	.	.	.	.	.	1	.	.	3⅔	....	.	.....	....	.	972
—2.00	16.32	.	29.31	29.33	29 31	29.84	28.46	29.31	.	1⅓	29⅔	.	3	9	1	..	2.170	1⅓	1	⅔	1⅔	.	⅓	1⅔	⅓	1	3⅓	2⅓	5⅓	5⅔	2	1⅓	⅓	2⅔	.	....	.	.....	....	.	954